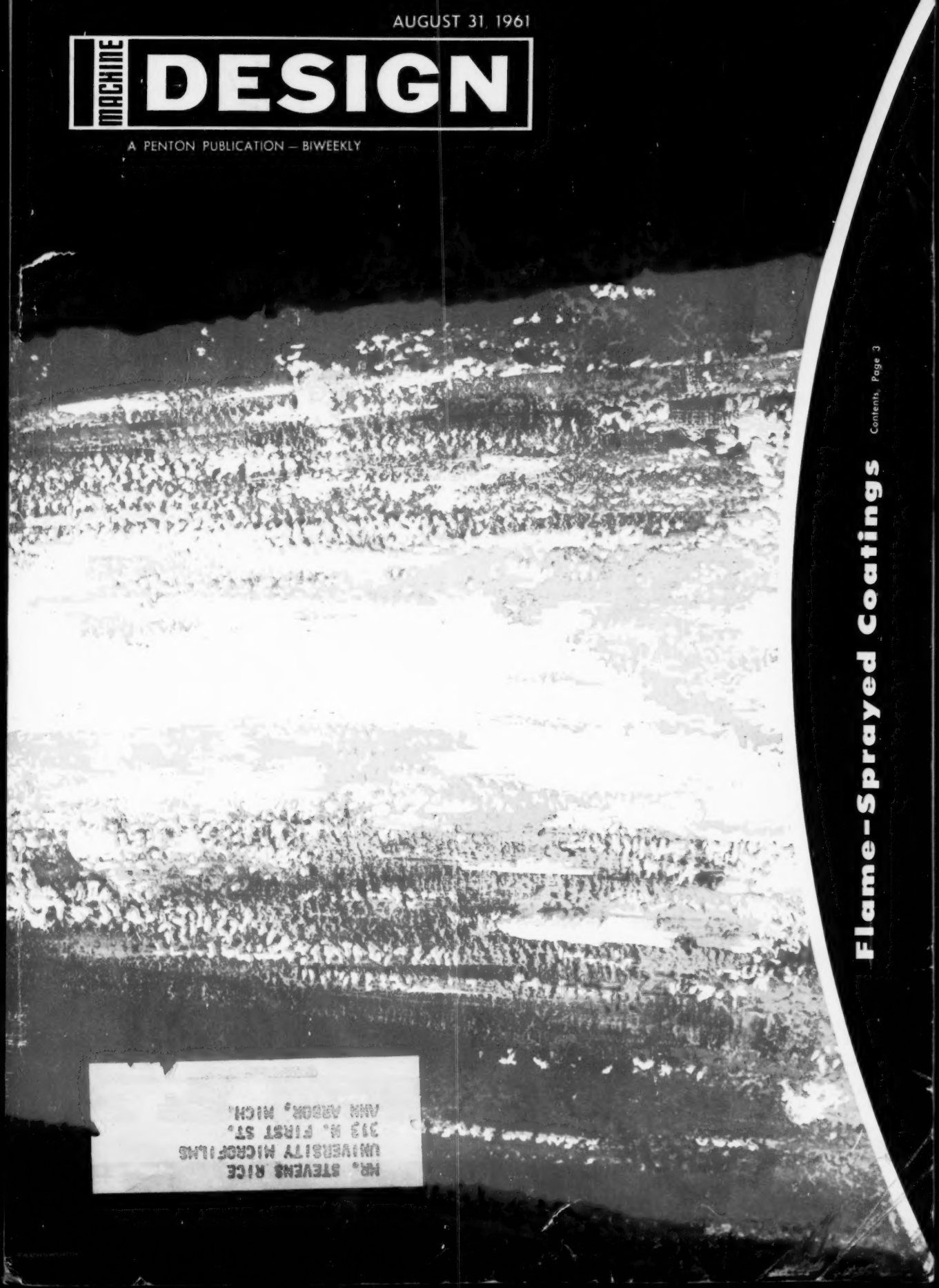
AUGUST 31, 1961

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Flame-Sprayed Coatings

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MR. STEVENS RICE
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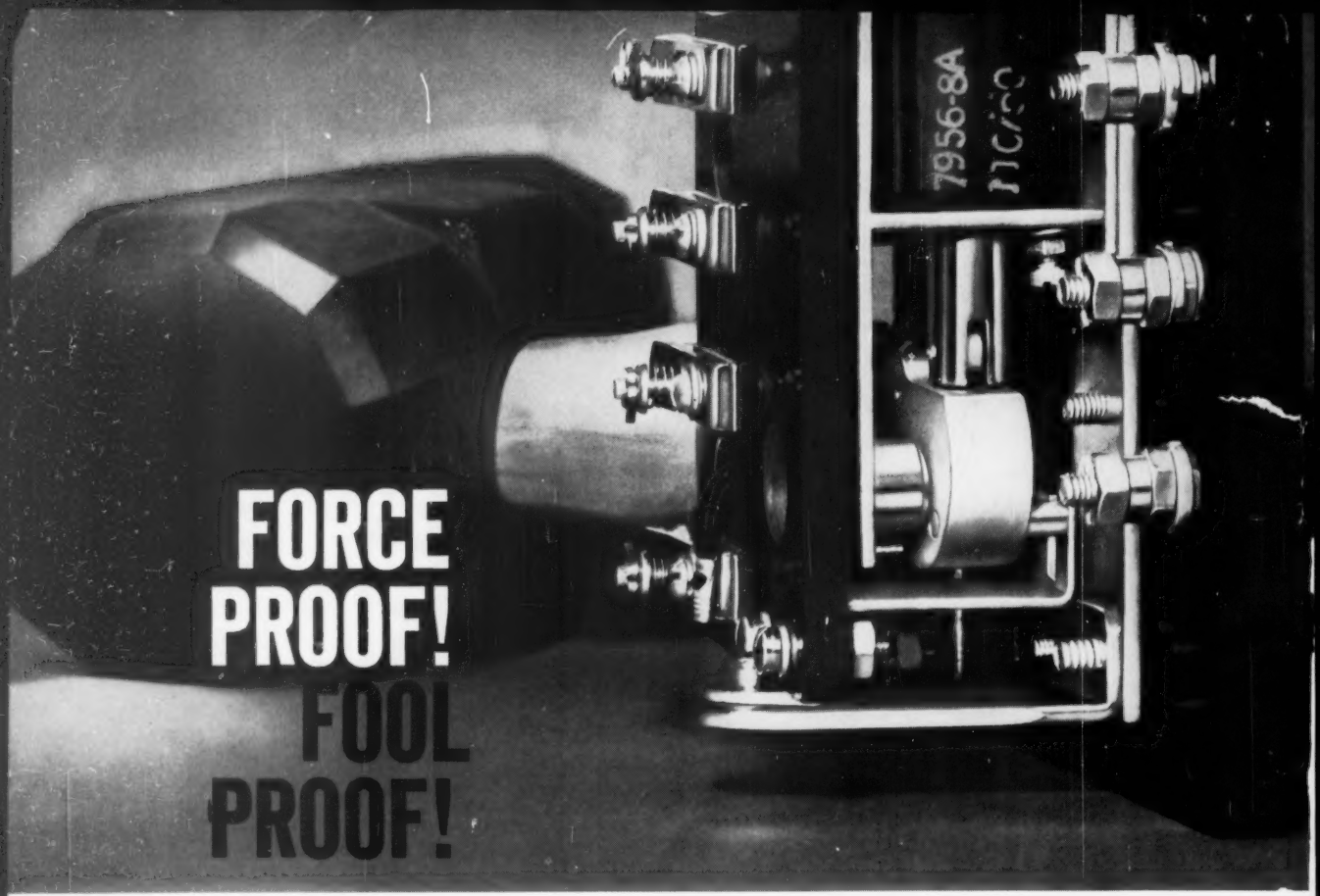
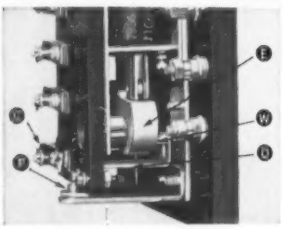
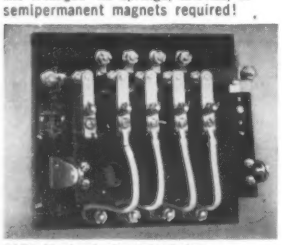




The Unique ASCO Mechanically Held Movement When the solenoid is energized, eccentric cam E is rotated. Weight drive pin W causes movement of operating lever D. Lever D (connected to the contact finger block) rotates on pivot pin P and contacts such as C are opened or closed.

With the solenoid de-energized, the entire mechanism is firmly locked in place by the angular position of the linkages—no springs, latches, or semipermanent magnets required!



ASCO Mechanically Held Relay

even **brute force** will not release the ingenious locking mechanism of **ASCO MECHANICALLY HELD RELAYS**

We don't recommend using it, of course; we just want to emphasize that, short of deliberate destruction of the linkages, only one force can release this powerful locking mechanism and change relay contact position. That force is normal energization of the solenoid coil. Nothing else will alter the angular relation of the linkages, which maintains positive contact pressure despite vibration, gravity, or control circuit failure.

The unique mechanical movement is the heart of any ASCO Mechanically Held Switch or Relay. At the instant of operation, a momentary surge of electrical power retracts the solenoid core to rotate a cam. Momentum carries the cam beyond dead center, and spring-loading completes the core-return stroke to relock the relay in the new position. Linkage action is the same whether contacts are opening or closing; thus the relay is power-driven in both directions.

Design simplicity, typified by the single-solenoid coil mechanism, and rugged, compact construction are characteristic of ASCO Mechanically Held Relays. Complex and less dependable elements such as hooks, latches, semipermanent magnets, or gravity-operated devices are not used. These ASCO relays operate in any position; without AC hum or chatter, and without derating for enclosure.

The extensive ASCO line includes a Mechanically Held Relay to meet your requirements precisely; single pole or in combinations of 24 poles; single or double throw; 10 and 25 amperes; to 250 volts DC, 600 volts AC.

Send for Relay Catalog 57-S4, which shows you how to select the optimum relay for your specific needs.

ASCO Electromagnetic Control

ASCO

DEPENDABLE CONTROL BY Automatic Switch Co. 54A HANOVER RD., FLORHAM PARK, N. J. • FRONTIER 7-4600 • *AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL*

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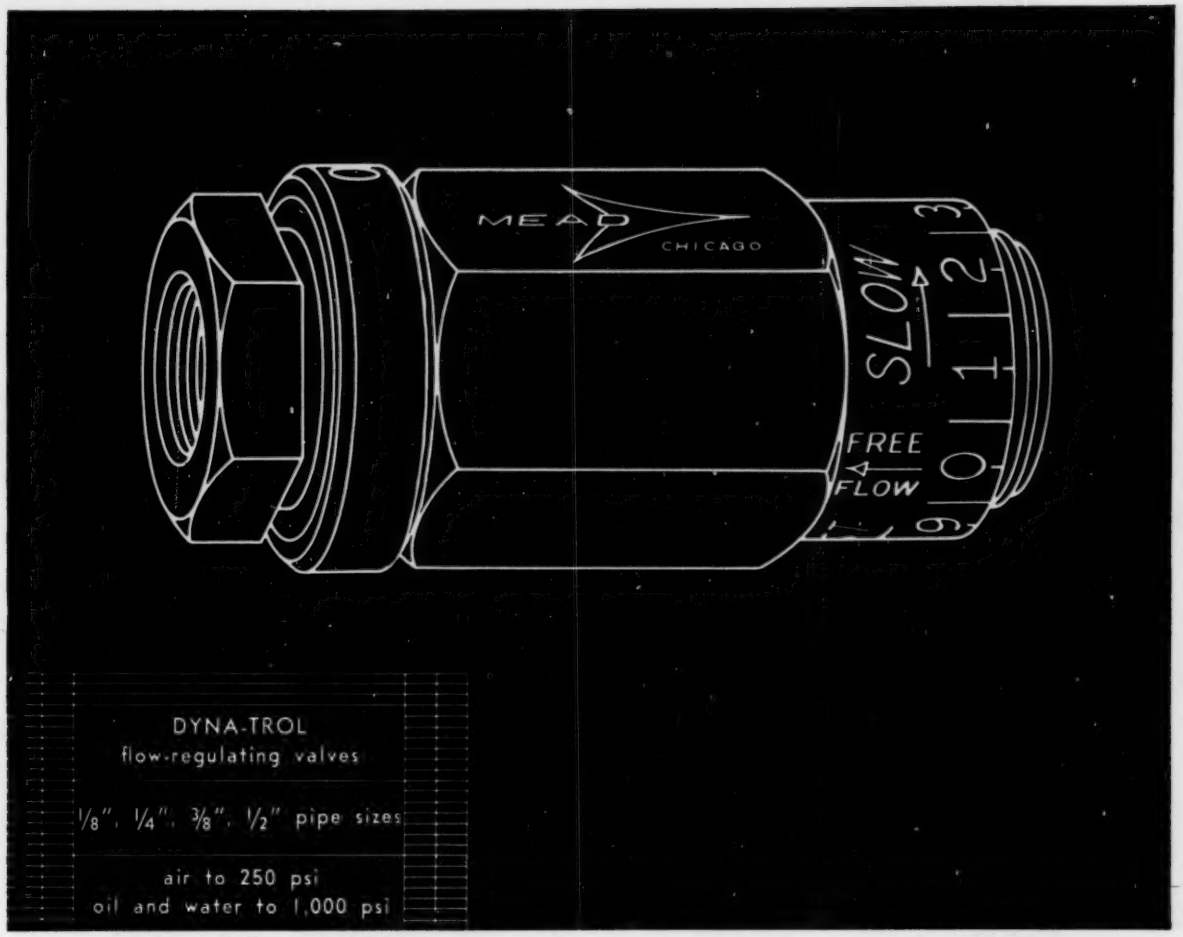

PROBLEM: how to replace a 1/4" valve with a less-costly 1/8" valve (and get extra precision in low-flow ranges)

SOLUTION: NEW MEAD DYNA-TROL VALVE

Check these design advantages of the new MEAD DYNA-TROL flow-regulating valve:

- Adjusting sleeve — easily rotated by hand — locks to any setting and cannot be accidentally removed from valve body
- Calibrated sleeve records settings for future reference
- Knife-edge variable orifice reduces flow distortion caused by viscosity changes in working medium
- No internal springs to cause malfunction
- All parts rust-proof
- Wide operating range: −40° F. to +250° F.

Small, economical MEAD DYNA-TROL flow-regulating valves can replace more costly valves of larger pipe size. Reason: Internal design permits pneumatic or hydraulic flow equal to full pipe area in both directions. The first 360° turn of the adjusting sleeve increases flow from zero to about 10% of potential — a new measure of precision in low-flow ranges. Successive turns accurately reach 100% of pipe capacity. To cut costs and give exacting control to piston speeds, specify MEAD DYNA-TROL valves to solve your flow regulating problems. For information on quick delivery, write to MEAD *today*.

PRODUCTS FOR AUTOMATION

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Circle 204 on Page 19

MINNESOTA MR RUBBER

FACTS for FILING on QUAD·RINGS®

- POSITIVE SEALING UNDER ALL CONDITIONS
- ELIMINATES ALL SPIRAL TWIST FAILURE
- FOUR FLEXIBLE SEALING SURFACES
- LOW FRICTION INSTALLATION
- HIGH DENSITY INJECTION MOLDED
- RUBBER COMPOUNDS TO FIT APPLICATION

POSITIVE SEALING UNDER ALL CONDITIONS
The MR QUAD-RING gives superior sealing in reciprocating, rotary, and static applications at pressures ranging from 0 on up.

ELIMINATES ALL SPIRAL TWIST FAILURE—This costly cause of O-ring failure is eliminated because the relatively square cross-section of the QUAD-RING will not roll.

FOUR FLEXIBLE SEALING SURFACES—gives double the sealing effectiveness of the O-ring because of the exclusive seal design. It prevents leakage and requires less squeeze.

LOW FRICTION INSTALLATION—is made possible because of the exclusive quadrilateral design. This permits much higher rotary speeds and gives the seal much longer life.

HIGH DENSITY INJECTION MOLDED—All QUAD-RINGS are molded by MR's exclusive injection molding process to give an exceedingly dense product. There are no voids to cause seal failure.

RUBBER COMPOUNDS TO FIT APPLICATIONS
MR compounds are designed to give the best possible service, using basic polymers such as natural or synthetic rubber, silicone or any other that will perform best under the specific conditions.

Quad Rings are manufactured under U. S. patents RE 24332 and 2,873,132

FOR MORE INFORMATION AND COPY OF THE QUAD-RING APPLICATION AND INSTALLATION HANDBOOK . . .

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Front Cover: Not a rocket exhaust, but George Farnsworth's artistic interpretation of the flame-spray coating process graces the cover for this issue. The symposium by Westerholm, McGeary, Huff, and Wolff, Page 82, completes the picture.

August 31, 1961

Nylon Parts Grow Up 24

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Midvac Steels are offered in many alloys (some are shown in table below) as billets or forgings for the production of forgings to meet the most critical design specifications of today's space age. Complete details on Midvac Steels, plus comparative analysis of leading super alloys are available in new Midvac Steel Booklet. Write for your copy to . . .

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Subsidiary of Heppenstall Company, Pittsburgh, Pa. **NICETOWN, PHILADELPHIA, PA.**

Alloy	Melting Process	Yield Strength .2	Ultimate Tensile Strength	Percent Elongation	Percent Reduction of Area
A-286	Air Melt	99,000 psi	132,300 psi	9.0%	14.7%
	Midvac	117,000 psi	150,500 psi	21.3%	33.8%
D6A-C	Air Melt	234,800	281,000	4.9%	20.6%
	Midvac	256,700	294,250	9.6%	28.4%
Tricent	Air Melt	238,600	284,500	6.1%	19.7%
	Midvac	254,300	291,600	10.3%	25.6%
901 Regular	Midvac	116,000	160,000	18.0%	25.0%
901 Hi-Strength	Midvac	131,000	179,000	19.2%	20.2%

Properties shown are averages of 25 heats

MH *Midvac Steels*

Circle 206 on Page 19

Wire-Guided Tank Killer Posts High Score

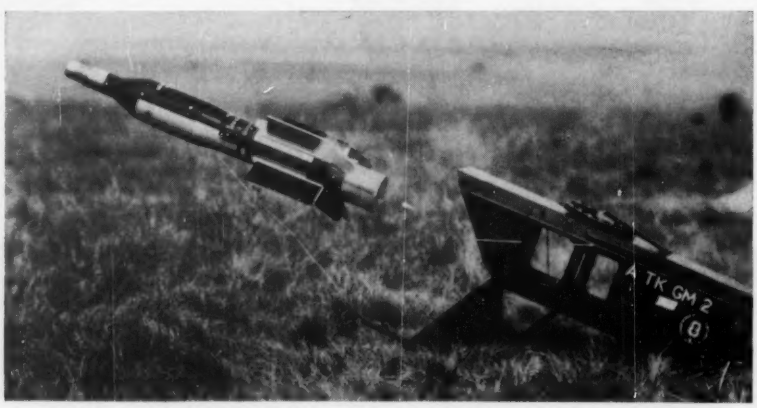
LONDON—In an impressive demonstration before ranking NATO officers, an English-designed, anti-tank weapon recently scored 10 hits in 12 shots squarely on the turret of a small moving tank. The weapon, known as the Vickers Vigilant, is a lethal one-man guided missile designed by Vickers-Armstrongs Ltd., British Aircraft Corp.

During the NATO demonstration, the tank, an American Patton, rumbled along behind a ridge at ranges between 430 and 1300 yards, with only half of its 3 x 6-ft turret visible. It suffered considerable damage, even though the missile was not armed. When armed, the hollow-charge warhead of the missile will reportedly penetrate the most heavily armored tank. The weapon has a payload capability of more than 36 per cent of its launch weight, permitting the use of a variety of warheads.

Stabilized and One-Man Portable

According to Vickers, the Vigilant is the only one-man, anti-tank missile in existence which is equipped with an autopilot. This so simplifies controls that British soldiers have scored six hits in as many shots during their first checkout with the weapon. The missile and its carry-box/launcher weigh only 44 lb and can easily be carried by one infantryman on a backpack.

Pistol-grip control unit simplifies aiming and firing of Vigilant. The wire-guided missile is controlled in flight by simple thumb movements; an auto pilot (gyro stabilizer) makes steering positive and direct. Minimum range of the weapon is 200 yards; maximum, 1 mile. The operator can be up to 75 yards from the launch point if he wishes to site the missile on a reverse slope. No flash is visible during launch, and the weapon trails no streak of smoke during its 340-mph flight.



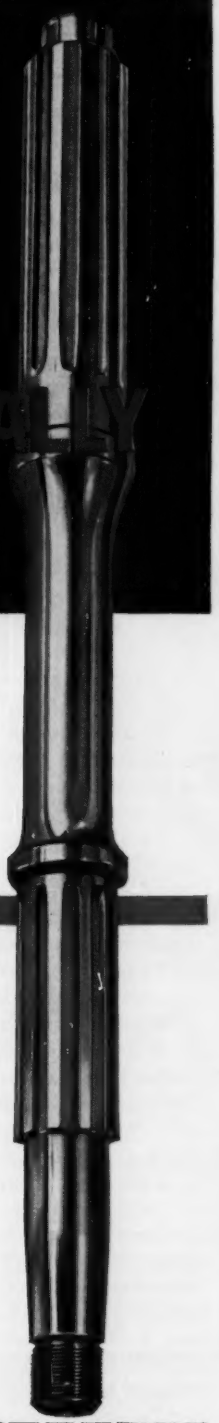
Rockwell-Standard
changes from hot-rolled A-4140 to

fatigue-proof®
STEEL BARS

elevated temperature drawing process **e.t.d.**

INCREASES
PRODUCTION SUBSTANTIALLY

— doubles tool life



Increases turning production 20%

Increases drill life 50%

Eliminates heat treating

Here's an example of how a small additional investment in material enabled Rockwell-Standard to increase production and cut cost on an axle for farm equipment.

Part: Axle for a self-propelled harvester.

Steel: FATIGUE-PROOF steel bars . . . replacing HR resulphurized A-4140.

Result: Heat treating eliminated. More uniform hardness across the section (302 Brinell) including small diameters. Hand straightening eliminated. Shaft runout in turning, reduced from an average of .015″ to .005″ in turning. Lower cost per part.

PRODUCTION INCREASES

Turning Operations: Speed increased approximately 45%. Tool life increased from 12 to 25 pieces per tip . . . tungsten carbide tips were used.

Drilling Operations: Drill life increased approximately 50% with FATIGUE-PROOF.

Milling Keyway: Entire lot of 550 pieces were run on one cutter . . . cutter formerly required sharpening after 300 pieces.

Hobbing Operations: Production increased approximately 60% . . . from 26 pieces per hour to 44.2 pieces per hour. Hob life doubled.

FATIGUE-PROOF steel bars offer all these cost cutting advantages.

No heat treating necessary—no quench cracks, warpage or other heat treating problems. Costly operations eliminated.

Exceptional Uniformity—from surface to center, end to end, bar to bar, size to size, and lot to lot.

Faster Machining—faster than annealed alloys; 50% to 100% faster than heat treated alloys.

La Salle STEEL CO.

1426 150th Street
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Send for FATIGUE-PROOF bulletin entitled, "A New Material." 24 Pages. Do it today!

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Circle 207 on Page 19

Cybertron: Another Thinking Machine

Pushing the "goof" button, when Cybertron errs, causes the machine to re-evaluate decisions and modify its memory. Tapes in background contain lessons and memory on various subjects. The machine excels at sonar and cardiogram analysis.

Many years ago, the mathematician Godel demonstrated in a classical paper that many problems do not lend themselves to logical solution—they can be solved only by experience. Today these "alogical" problems include such vital military tasks as the differentiation of real and false radar echoes. Raytheon's Cybertron, one of a new breed of machines, is designed to solve alogical problems. Faced with the task of separating true target echoes from spurious radar signals, Cybertron provided information for the design of new filters which are more discriminating than any previous units.

LEXINGTON, MASS.—A special purpose machine "so nearly human that it learns, makes decisions, profits by its mistakes, and tells how to solve problems that baffle man," has been developed by Raytheon Co.

Called Cybertron by Raytheon, the machine is "alogical"—it learns by trial and error, relating new situations to past experience, constantly improving its skill.

Two models of Cybertron have been developed. The smaller version, K100, is working on classified military problems for the Department of Defense. K200, now in final stages of development, is a much larger machine, and is designed to take dictation. When fully developed, it will be capable of recognizing and typing out all typical American word sounds.

Pitted against veteran sonar operators in separating real from false target echoes, Cybertron learned in hours techniques that normally take human operators many months to learn.

According to Raytheon, Cybertron will be suited for a broad range of military and industrial applications. In canneries, learning machines could be taught to sort and grade produce. They could perform similar quality control and inspection procedures in many other industries. These machines thrive on repetition, continually refining learning and performance.

Since Cybertron's learning is in the form of signals, the machine's brain can be picked by similar machines hundreds of miles away. All it knows can be transmitted by conventional communications systems.

Once Cybertron has mastered a particular task, its know-how can be transferred to an AIDE (Adapted Identification Decision Equipment), a simpler, more compact machine which can perform the task but cannot do any further learning.

Topics

A five-pound package of money may never be needed, but a new machine can make up bundles of bills—at the rate of 3600 an hour. The amount to be in a package is preset on the machine, and suction devices pick up bills from trays and place them on a wrapping band. This band is automatically sealed, then thickness of the package is checked electronically. The money counter is built by Currency Pre-Packaging Machine Co.

• • •

Poetry on punched cards has proved, to the satisfaction of at least one computer and one classical scholar, that Homer was the sole author of the *Iliad*. Until recently, this work has been considered a collection of separate ballads; now the tendency is to accept all the poems as Homer's. In preparing his doctoral dissertation, James McDonough, a graduate student at Columbia University, prepared an IBM card for each of the more than 15,000 lines of the *Iliad*. His code indicated metric contour of the line—where words begin and end and where long and short syllables are. The computer's detailed analysis is said to reveal style mannerisms that could not have been imitated by another poet. By using the machine, Mr. McDonough was able to complete—in four years—a study that would have taken 20 to 40 years in the pre-computer era.

• • •

Old reliability: During a recent tour of vintage automobiles in England, just one car had mechanical difficulty. It was the escort vehicle, a 1961 model.

• • •

A popcorn production line has been set up to take care of hungry spectators at the Los Angeles Coliseum. A conveyor system, equipped with 155 ft of Goodyear Koroseal belting, extends from a bank of five corn poppers to a large stainless-steel hopper where the corn is packaged. Time from popper to hopper is five minutes.

• • •

New light on the firefly and what makes him glow has been shed by the research of two Johns Hopkins chemists. Drs. W. C. McElroy and E. H. White list five substances which make the light: Oxygen, certain magnesium salts, adenosine triphosphate, and luciferon and luciferase—two substances unknown before this analysis. Dr. White has synthesized luciferon in the laboratory. He can make about one gram of it—about the same amount found in 2 million fireflies.

Please direct inquiries to advertiser, mentioning MACHINE DESIGN→

... Fluid Power news

OILGEAR 40 Years of Fluid Power

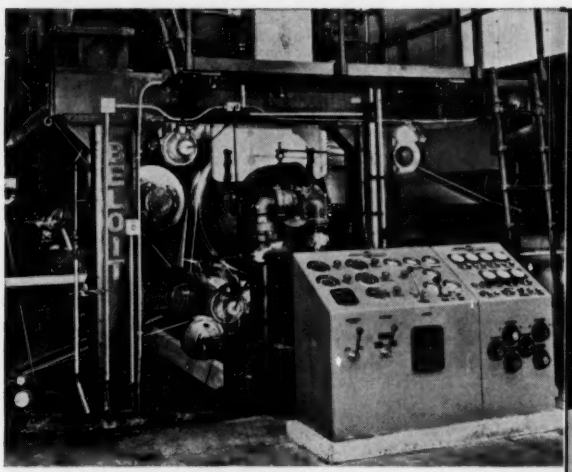
Report No. 12,107 From Oilgear *Application-Engineering* Files

HOW *HYTAC** SYSTEMS CONTROL NEW EXTENSIBLE PAPER MACHINE SECTION SPEEDS IN 12 MILLS

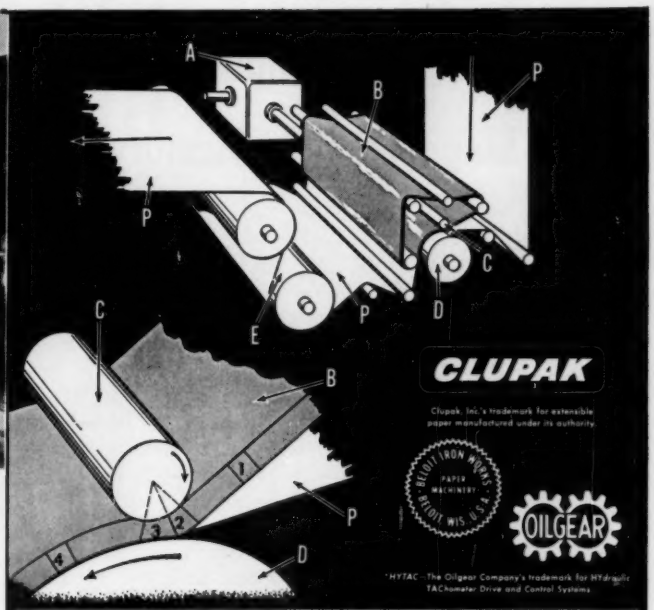
USERS: *Twelve Paper Companies—Licensed by CLUPAK, INC.*

Builder—Sections and Differential Drives—Beloit Iron Works, Beloit, Wisconsin

DATA: Systems to vary and precisely control speed and draw of new sections that can be an integral part of complete, new paper machines, or inserted into existing machines for production of CLUPAK® extensible paper—a revolutionary, patented, smooth, tough, kraft sheet. Original requirements called for systems that, when applied to *Beloit* mechanical differentials, would: *1.* Provide precision-controlled, infinitely variable section speed decrease up to 10% under main lineshaft speed—as selected from remote pushbutton stations. *2.* Maintain selected section speed within ±0.25% max. variation over a 50% load change at max. lineshaft speed. *3.* Be: compact; impervious to heat, high humidity; thrifty on electrical power input, wiring, installation downtime, floor space; completely free, if possible, from maintenance-provoking belts, chains, relays. *4.* Insure trouble-free, continuous, heavy-duty, full-production paper machine drive service—but permit section immobilization for production of non-extensible stock. *5.* One source and responsibility for these speed and draw controls preferred.



One of the most recent of the twelve new **Beloit** extensible sections and control consoles incorporating **HYTAC* SYSTEMS** for precise speed and draw control—as installed on No. 1 machine at **International Paper Company's Southern Kraft Division Mill, Camden, Arkansas,** to produce CLUPAK® extensible paper. Control console instrumentation includes direct-reading hydraulic pressure gages from the **OILGEAR System** to provide operators with constant, visual, exact indication of load or draw on the section.



HOW IT WORKS: Section driven by Oilgear-equipped **Beloit** differential (A), consists of a 1-in. thick natural rubber Blanket (B) operating over 3 rolls, and between Nip Roll (C) and steam-heated, polished, chrome plated Dryer Drum (D). Paper (P) is held between Blanket (B), slipping against Dryer Drum (D). Enlarged view at Nip Roll shows how normal (1) Blanket (B) is compressed (2), squeezed and elongated (3), and rapidly contracts (4) after leaving Nip Roll—shrinking paper. Normal production shrink requirement is accurately controllable up to 15% by controlled variation in nip pressure, moisture content, dryer drum temperature. Accurate control of draw in and between extensible unit and 3rd Dryer Section (E) is required regardless of load changes . . . a reason for the precise, infinitely variable speed-draw control provided by Application-Engineered **HYTAC* Systems.**

SOLUTION: Application-Engineered *HYTAC** (HY*draulic* TAC*hometer*) controlled differential drives consisting of Oilgear "DRt-3517" Variable Displacement Pumps, "H-6017" Constant Displacement Motors, and *HYTAC** components with remote pushbutton control to provide precise speed-draw control on *Beloit* extensible sections installed and commercially producing CLUPAK® extensible paper at nine mills in the United States, two in Canada, and one in Sweden. Several other paper manufacturers licensed by CLUPAK, Inc., to produce extensible paper under its authority, now have these Oilgear-equipped *Beloit* extensible sections on order. Oilgear *HYTAC** Drive-Control Systems were selected after 3 years of development on this process and machine—from a 2-in. table model, through a 15-in. laboratory model, and a 60-in. pilot model—as best suited to provide the accuracy and range of control required for the variable speed drives. *Actual commercial operation has proved that these highly accurate, compact, heavy-duty, Oilgear Systems can maintain any selected section speed with less than ±0.25% variation* regardless of load change *over a 10:1 range of lineshaft rpm—plus enabling operators to infinitely vary each section's drive rpm up to 15% under main lineshaft rpm . . . exceeding originally specified requirements!*

Other inherent Oilgear "Any-Speed" Drive features are: cushioned, controlled starting, acceleration, deceleration, braking . . . positive, automatic overload protection . . . continuously filtered pressure and flood lubrication. Copies of Oilgear's *Fluid Power NEWS* 3, 5, 8, 9, 11—with detailed descriptions of some of these and other *Application-Proved* installations are available on request.

For practical solutions to your linear or rotary Controlled Motion problems, call the factory-trained Oilgear Application-Engineer in your vicinity. Or write, stating your specific requirements, directly to . . .

THE OILGEAR COMPANY

Application-Engineered Controlled Motion Systems

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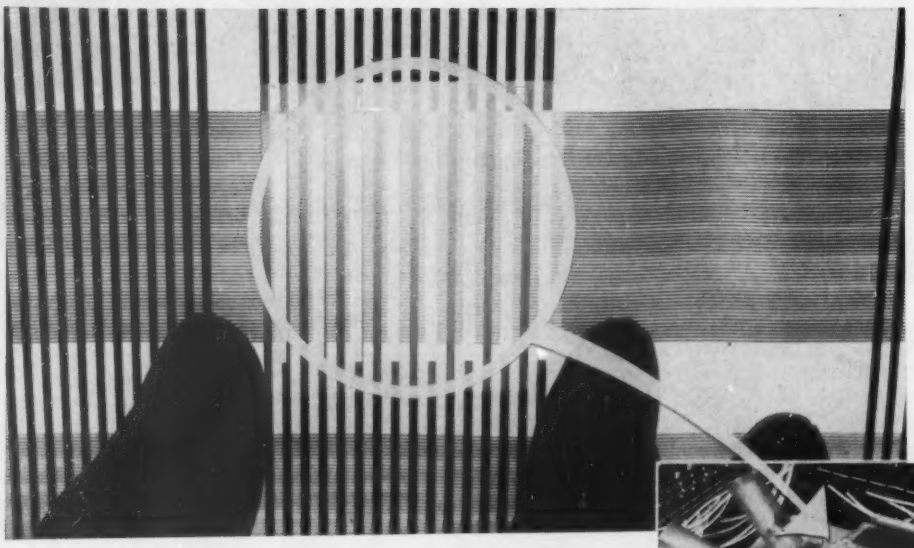
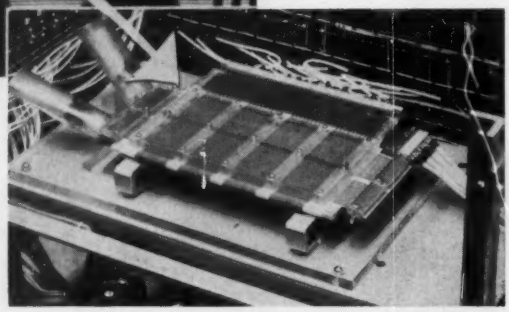


Glass plate, with small rectangular magnetic-film memory elements, is placed on printed-circuit wiring in the assembly of FX-1's high-speed memory. Each magnetic-film element rests on the intersection of two perpendicular leads on a flexible plastic wiring sheet. Completed circuitry (below) contains the 256-word, 3328-bit memory of the computer.



Fastest Digital Computer Tries Magnetic-Film Memory

LEXINGTON, MASS.—The fastest digital computer ever built is now in operation at MIT's Lincoln Laboratory. Known as the FX-1, the new machine is described by MIT as being a working model for a new generation of computers which will be ten times faster than any in general use today.

In addition to its speed, FX-1 also incorporates new construction techniques designed especially for high-frequency operation. It is, for example, the first machine with a main memory using thin magnetic films in place of ferrite cores for high-speed, random-access storage.

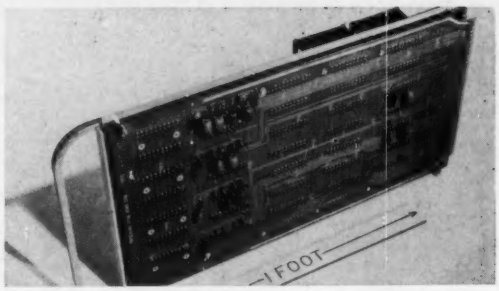
In comparing the speed of the FX-1 to that of other computers, two operations are measured:

- Time required to read a computer word out of the memory and to write in a new word (read-write cycle time).
- Speed of the logic circuits, specified by the rate of the timing pulses which govern the operation of these circuits (clock rate).

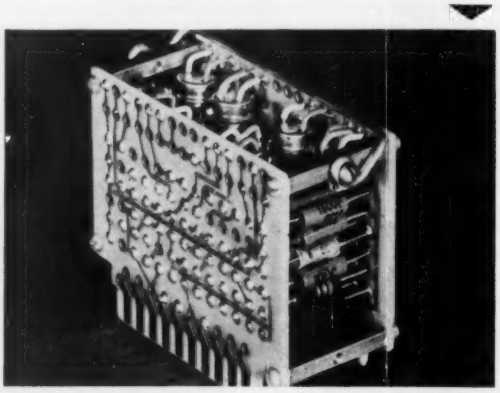
Read-write cycle time for the central memory of the FX-1 is 0.3 microsecond. The fastest main memories in machines today (all use magnetic cores) have cycle times ranging from 2 to 12 microseconds.

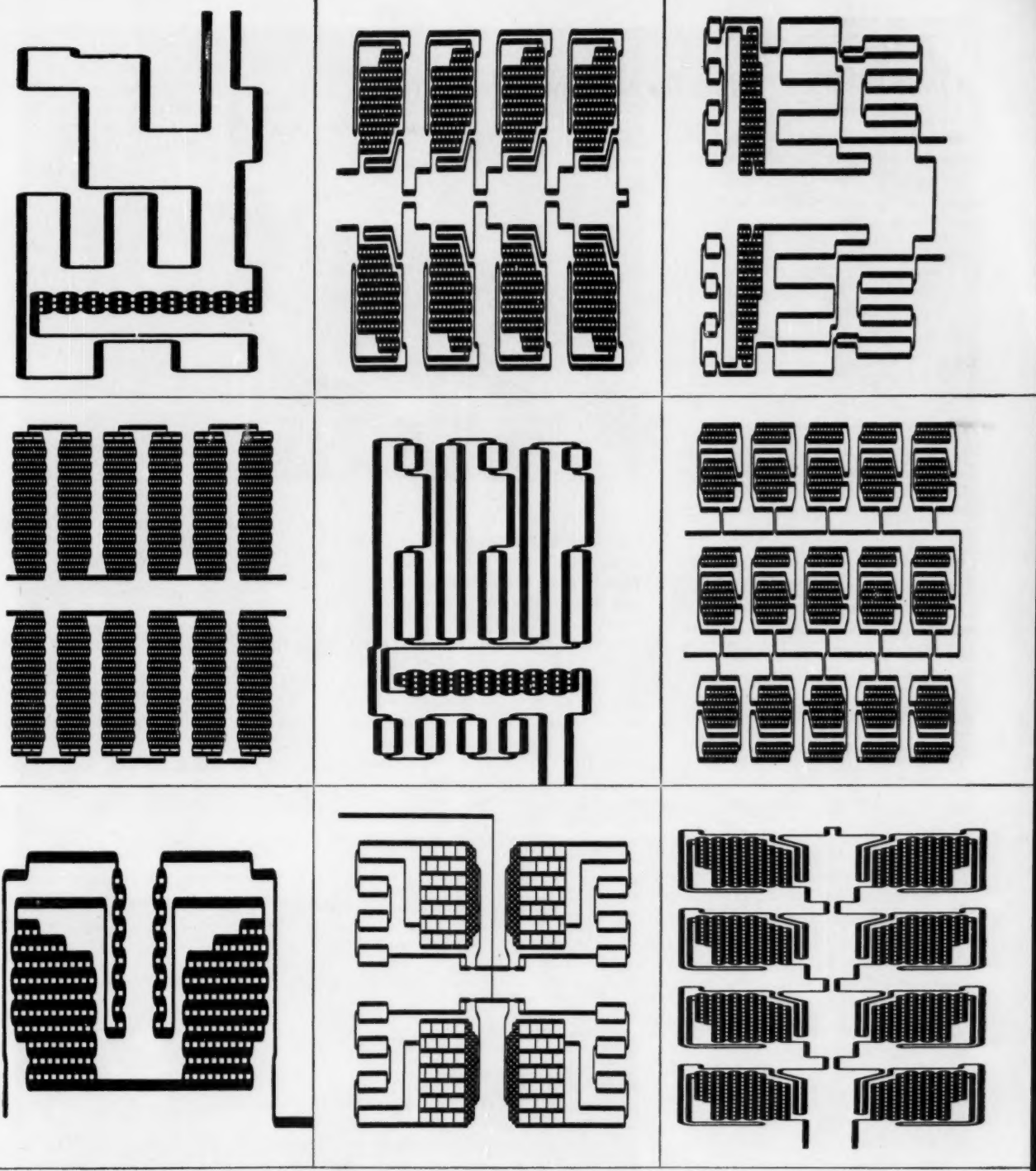
Logic circuits in the FX-1 operate at an effective clock rate of 50 million pulses per second, ten times faster than most machines currently in operation, and four times the rate of the fastest commercial machine available.

Several circuit trays in the FX-1 are fabricated by a developmental technique called plated-circuit wiring. This consists of two layers of etch wiring sandwiched on either side of a central copper ground plane. Wiring of this type behaves like strip-transmission line, having uniform impedance characteristics that should simplify and improve circuit performance at high frequencies.



Plated-circuit tray has two layers of wiring on either side of a central ground plane which functions as strip transmission line with uniform impedance characteristics. This type of construction is being tested in the FX-1 to simplify and improve circuit performance at very high frequencies. Typical plug-in unit, for logic circuitry, is 1.75 x 2.25 x 1 in. Approximately 325 of the units are used in the computer, mounted in trays that accommodate up to 20 plug-in units each.





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METALS DIVISION

Circle 209 on Page 19

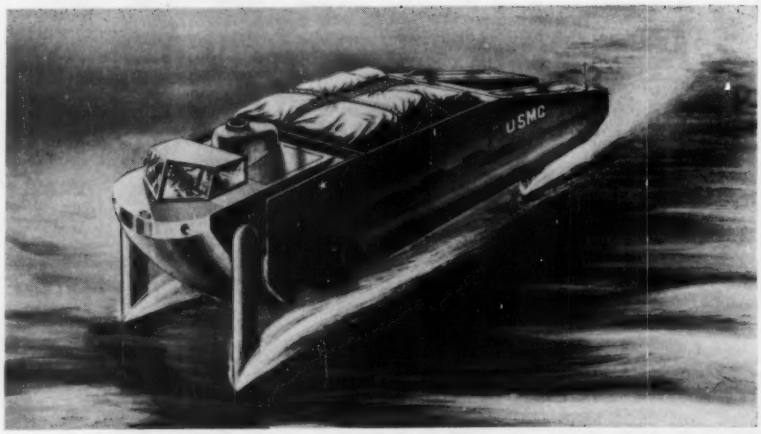
Marines Replace 'Sitting Ducks' with Flying Variety

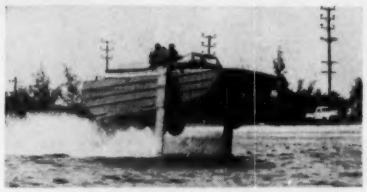
STRATFORD, CONN.—A turbine-powered hydrofoil capable of transporting several thousand pounds at speeds of 45 knots will be built for the Marine Corps by Avco Corp., Lycoming Div.

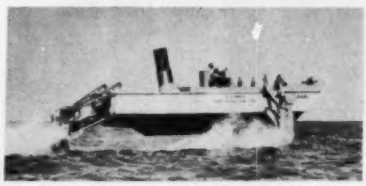
Known officially as the LVH, or Landing Force Amphibious Support Vehicle, Hydrofoil, the new craft will be used as a high-speed cargo carrier during assault landings.

Powered by a Lycoming TF-1430 multi-fuel gas turbine, LVH will have a flying speed in excess of 45 knots, boating speed of 5-10 knots, and overland speed of more than 25 mph. Foils, which are retractable during land travel, are self cleaning and have been structurally designed to operate through floating debris without damage.

The craft has been equipped with separate propellers for boating and flying operations. The flying propeller is mounted on the bottom of the rear strut; the entire lower section of the strut, including the foil and propeller, is rotatable to provide dynamic steering. The boating propeller is mounted on a retractable drive beneath the hull.







Evolution of the Marine Corps' LVH: Flying Duck (right), a converted World War II DUKW, proved the feasibility of hydrofoil landing craft. The ungainly vehicle would operate at speeds of more than 35 mph, as compared to its normal pace of 6 mph. Gas turbine-hydrofoil combination was tested by the Halobates (right, below), a converted Navy LCVP. In operation since 1959, the craft has a top speed in excess of 35 mph. Artist's sketch (above) shows final configuration of the Marine's hydrofoil landing craft.

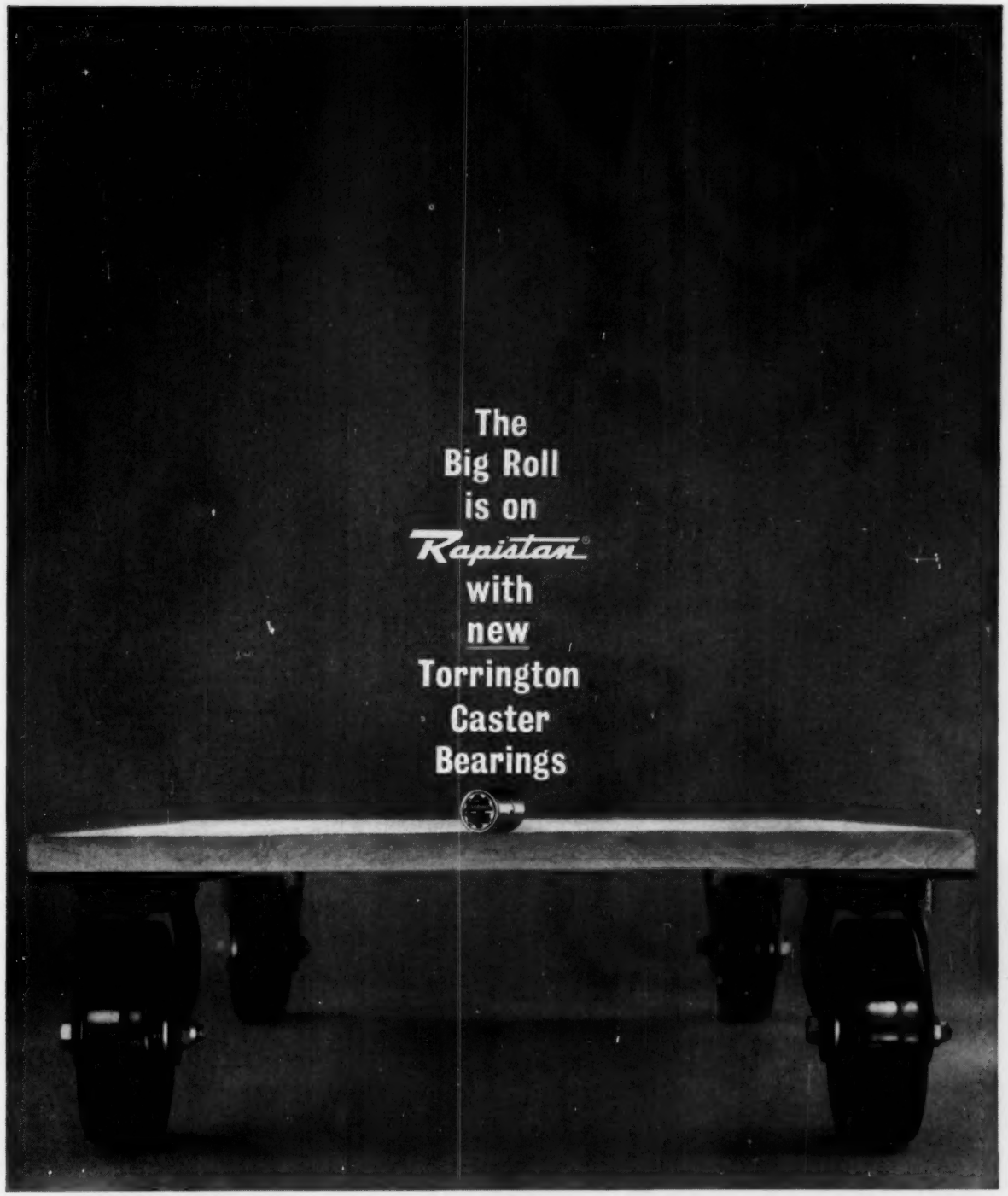
Maser Amplifies Light

NEW YORK—A pulsed ruby maser was recently operated as a light amplifier at Bell Telephone Laboratories. In the experiment, two ruby masers were set up in tandem. A pulse of light from one, used as an oscillator, was beamed into the other which amplified the light by a factor of two.

Although other researchers have reported that maser oscillators amplify light sufficiently to compensate for losses at end mirrors, this is the first experiment reported that was designed to observe and measure amplification directly.

The problem involved in directly observing amplification is one of distinguishing coherent maser light from the natural fluorescent light of the maser. In the experiment at Bell Labs, this difficulty was overcome by using a ruby-maser oscillator to generate a coherent light which was so bright that the fluorescence was comparatively small. The amplifying ruby was similar to the light-source ruby except that the ends of the ruby rod were not silvered.

Amount of gain that can be obtained depends on the temperature of the amplifying maser and the pumping power. A net gain of two was observed at −40 C. With a more precise experimental setup and greater control of temperature, Bell researchers report a larger amplification could be obtained.



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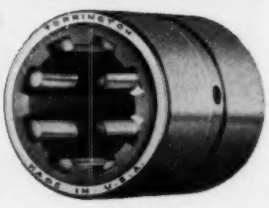

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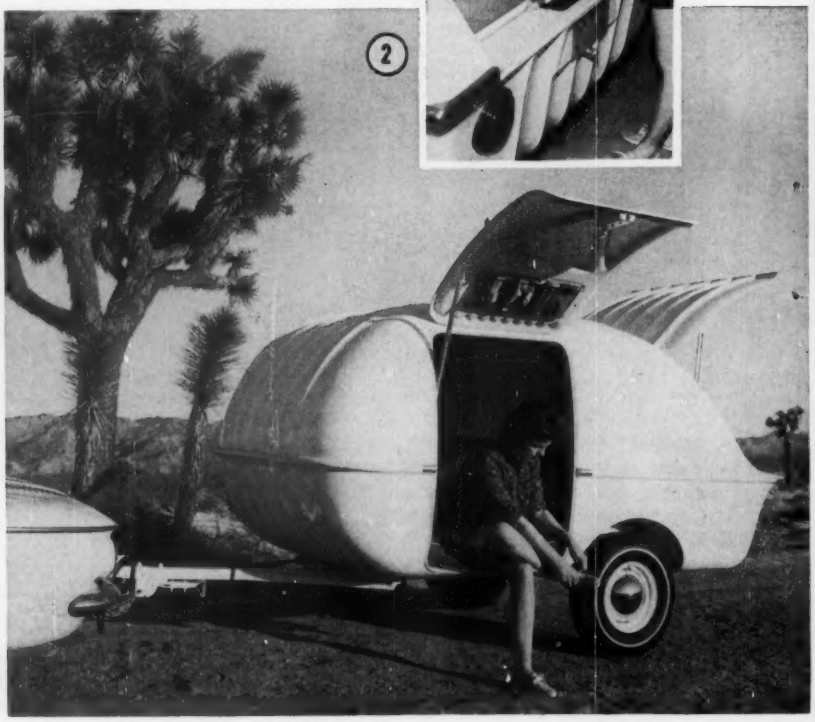
Circle 210 on Page 19

Industrial Design

comments and configurations

Treat for the tricycle set is provided by swivelable back wheels, a feature of the Twirly Trike designed by American Machine & Foundry Co.(3). "Shifting," by means of the handlebar control lever, converts the vehicle from a conventional tricycle to one which will make sharp turns and travel in a zig-zag pattern.

Two molded-plastic trailers add to the pleasure of camping. The 10-ft Trailorboat (1), by Trailorboat Engineering Co., San Rafael, Calif., carries a 75-lb boat and has a pull-down back door which forms a table and exposes cooking and storage areas. The Towhee (2), a product of Barton Industries, North Long Beach, Calif., is slightly under 9 ft long, weighs 500 lb. Its cooking area has a butane stove, 10-gal water tank, and ice chest. Both trailers and the boat are molded from glass-fiber reinforced Vibrin polyester produced by the Naugatuck Chemical Div., U. S. Rubber Co.



Harmonic of Light Produced for First Time

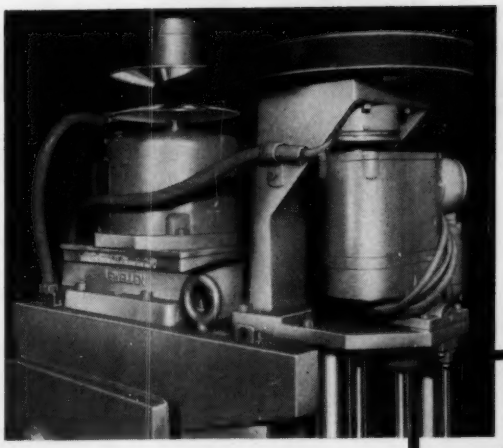
ANN ARBOR—Using an extremely powerful laser (light amplification by stimulated emission of radiation), University of Michigan physicists have scored a scientific first by producing an overtone of a beam of light. The achievement is potentially of great importance in the field of communications.

The U-M group produced the second harmonic (or overtone) of red light by focusing the laser's intense beam of pure red light into a quartz crystal. The second harmonic was a deep blue beam. The laser beam was monochromatic at 7000 Angstroms. The blue beam, an almost invisible violet which was considerably weaker than the laser beam, was monochromatic at 3500 Angstroms.

As a source of the intense red beam, U-M physicists used "one of the most powerful lasers in the world." It produced a power density of 100 million watts per square centimeter at the focus. By contrast, the intensity of sunlight at the earth's surface is 0.1 watt per square centimeter.

"This is a striking example of optical electronics," the U-M group said. "Although the production of the second harmonic is now relatively weak, the possibilities for unique devices based on this effect merit intense investigation." One possibility: The use of electromagnetic waves in the frequency region of light for communication purposes. For this, the light beam must be modulated (or mixed), as are radio waves, to carry a signal. If this is achieved—and the U-M group points out that there are many difficult problems to be solved—beams of light would be constructed with a message-carrying capacity many times that of the longer radio waves. A single light beam, for example, could carry all the messages that now go across country on regular communication channels.

Another important application would lie in the investigation of materials' properties that scientists are presently unable to study (i.e., investigation of non-linear optical characteristics).



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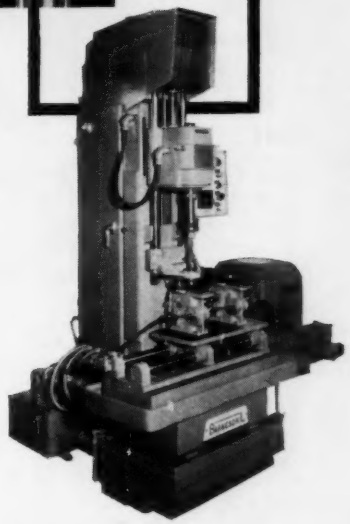

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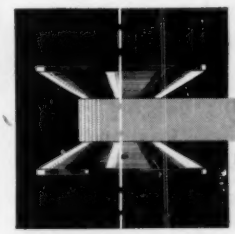

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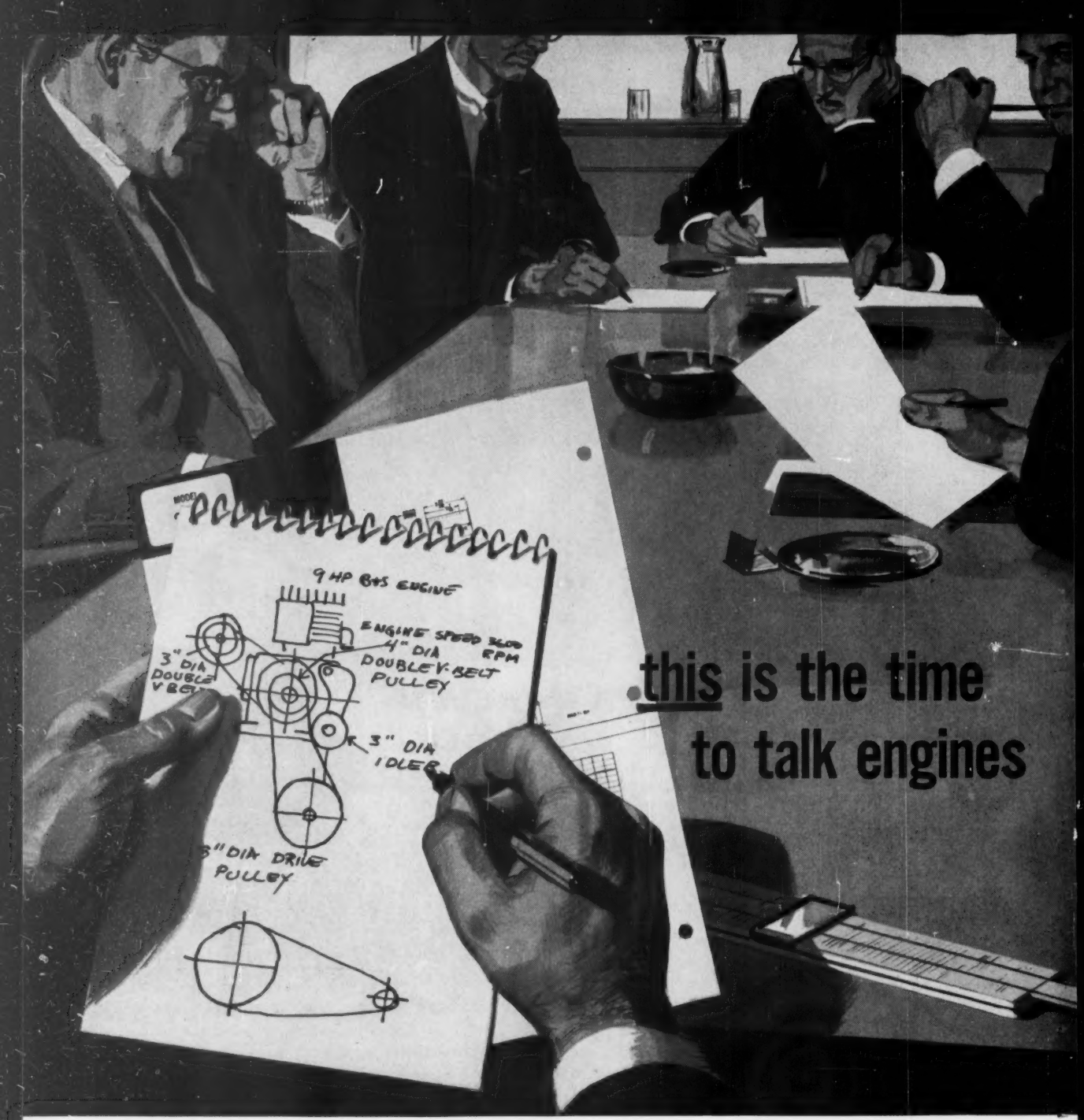

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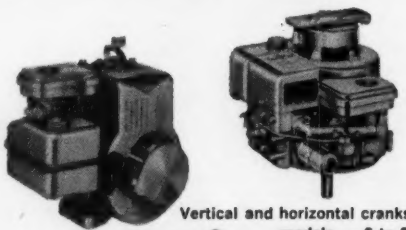

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501 Electronic Transformers. 28 pp. General Electric Co.

509 Adjustable Sequence Timer. 4 pp. Space Instrumentation Div., Technology Instrument Corp.

513 Wire-Wound Potentiometers. 6 pp. Fairchild Controls Corp.

520 Governors, Switches. 12 pp. Synchro-Start Products Inc.

521 Slip Rings; Brush Assemblies. 16 pp. Slip Ring Co. of America.

527 Magnetic Drives. Louis Allis Co.

566 Variable Transformers.* Adjust-A-Volt units for bench or panel mounting. Catalog Section 1, 40 pp. Standard Electrical Products Co.

567 Engine Controls.* Series 46 and 56 units for gas, gasoline, or diesel engines. Bulletin 601, 12 pp. Synchro-Start Products Inc.

568 Printed Circuits.* Specifications for all types of circuits, including Carte Blanche units. "Depth in Circuitry," 14 pp. U. S. Engineering Co.

569 Precision Resistors.* Molded metal-film units for electronic apparatus. Catalog 50, 6 pp. Ward Leonard Electric Co.

570 Panel Instruments.* Series 1900 ammeters, milliammeters, microammeters, voltmeters. Bulletin 01-113, 6 pp. Weston Instruments Div., Daystrom Inc.

571 Selenium Rectifiers.* Certified selenium cells and stacks; cartridge-type rectifiers. Bulletin 400, 4 pp. Semiconductor Div., Syntron Co.

572 Mesa Transistors.* No. 2N834 and 2N835, silicon, NPN, double-diffused units. Bulletin DS 5015 R1, 8 pp. Motorola Semiconductor Products Inc.

573 Numerical Control.* Defines meaning of numerical control; explains use of punched tape in machine-tool applications. 32 pp. Friden Inc.

574 Miniature Potentiometers.* In ranges from 0-10 to 0-5000 psia. Trans-Sonics Inc.

575 AC Gearmotors.* Fractional-hp, in-line and right-angle units. Bulletin 1300 G, H, 2 pp. Ohio Electrical Mfg. Co.

576 Control, Torque Synchros.* Size 11, 400-cycle, three-bore synchro selection. Data Sheet CS/TS-4-11-1, 4 pp. Vernitron Corp.

577 Shell-Type Motors.* In ratings from ½ to 150 hp. Bulletin 107, 4 pp. Louis Allis Co.

578 General-Purpose Relays.* Type GR units are simple, rugged. Bulletin 166, 4 pp. Ohmite Mfg. Co.

Hydraulic, Pneumatic

502 Rotary Pumps. 8 pp. Roper Hydraulics Inc.

503 Instrument Gages. 12 pp. Republic Flow Meters Co.

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511 Fluid Motors. Char-Lynn Co.

516 Leather Packings. 12 pp. Garlock Inc.

526 Air-Control Products. 48 pp. A Schrader's Son, Div., Scovill Mfg. Co. Inc.

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532 Pilot Valves. 4 pp. Oilgear Co.

579 Control Valves.* Series LB all-purpose units have split-body design. Bulletin LB-4, 16 pp. Conoflow Corp.

580 Seals and Fasteners.* Hexseals, Seelscrews, Seelbolts, Rubrglas Seel. Catalog 359B, 16 pp. A.P.M. Corp.

581 Air Valves.* In sizes from 0.93 to 4.4 in. Bulletin F-10539, 4 pp. Barber-Colman Co.

582 High-Pressure Valves.* Have capacities of 3000 and 6000 psi. Bulletin 280-B, 8 pp. Watson-Stillman Press Div., Farrel-Birmingham Co. Inc.

583 Gasket Material.* Styles of gasket materials available; gasket design. Form AD-190, 24 pp. Garlock Inc.

584 Vane-Type Fuel Pumps.* Points out advantages of fixed-displacement, vane-type pumps. Bulletin A-5242A, 6 pp. Vickers Inc., Div., Sperry Rand Corp.

585 Vacuum-Pump Selector.* Slide rule for choice of rotary air-pump models. Gast Mfg. Corp.

586 Premium Lubricants.* Concept of molybdenum-disulfide additives used to enhance temperature capabilities. 20 pp. Hercules Packing Corp.

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588 Fans, Air Washers.* Vinyl plastic fans, air washers, exhaust systems. Catalog F, 36 pp. Industrial Plastics Fabricators Inc.

589 Centrifugal Pumps.* Type GBH close-coupled, end-suction units. Bulletin 108, 6 pp. Aurora Pump Div., New York Air-Brake Co.

590 Pressure Regulator.* Type 10 units in models with 2 to 120 psi. Bulletin LC 100, 4 pp. Lexington Controls Inc.

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593 Sprockets and Hubs.* Includes formulas for selection of shear-pin hubs and sprockets. Catalog CD-104-A, 4 pp. Browning Mfg. Co.

594 Roller Chain and Sprockets.* Data on power-transmission plans and ideas. Catalog 8, 106 pp. Acme Chain Corp.

Assembly Components

506 Pin-Type Fasteners. 4 pp. Driv-Lok Sales Corp.

525 Industrial Casters. 4 pp. Faultless Caster Corp.

595 Standard Plastic Parts.* Illustrates variety of Dako-ware knobs, handles, balls. Catalog 9, 12 pp. Harry Davies Molding Co.

596 Casters and Wheels.* Contains glossary of caster terminology and selection chart. Catalog 150, 48 pp. Hamilton Caster & Mfg. Co.

597 Stainless-Steel Screws.* Unbrako KS 812 socket-head cap screws discussed. Form 2734, 4 pp. Standard Pressed Steel Co.

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531 Beryllium-Copper Rod. 8 pp. Beryllium Corp.

598 Silicone-Rubber Products.* Properties, applications of a range of products. Bulletin 5901a, 12 pp. Hewitt-Robins.

599 Polycarbonate Films.* Physical, electrical properties of Lexan films. Report CDC-396, 14 pp. Chemical Materials Dept., General Electric Co.

600 Rhenium, Rhenium Alloys.* Discusses fabrication, applications, and varieties. 12 pp. Rhenium Div., Chase Brass & Copper Co.

601 Plastic Optical Lenses.* Bolsey Frenelenses can replace glass lenses in optical applications. Brochure 6104-10T, 8 pp. Stocker & Yale Inc.

602 Beryllium-Copper Strip.* Covers two high-strength and two high-conductivity products. 16 pp. Brush Beryllium Co.

603 Vinyl Resins.* Elvax vinyl resins, designed for compatibility with paraffin wax. Bulletin A-18749, 14 pp. Vinyl Products Div., Electrochemicals Dept., E. I. duPont de Nemours & Co.

604 Aluminum Casting Alloy.* Precedent 71 high-strength, shock-resistant alloy in two forms. 8 pp. William F. Jobbins Inc.

605 Resistance Alloy.* Properties, performance characteristics of Alloy 750, for use as heating elements. Bulletin 112, 8 pp. Hoskins Mfg. Co.

606 Vinyl-Aluminum Laminate.* Contains sample of Vynalate material and chips of 39 color-pattern combinations. 20 pp. Aluminum Co. of America.

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515 Pressure Transducers. 4 pp. Consolidated Controls Corp.

518 Drafting Machines, Tables. 4 pp. Ozalid Div., General Aniline & Film Corp.

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Descriptions start on Page 126.

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535 Miniature gear motors in end or side-mounted types. Globe Industries Inc.

536 Photoconductive cell is miniature unit which measures tungsten or daylight. Clairex Corp.

541 Subminiature switches have only two moving parts. Contacts & Specialties Div., Fansteel Metallurgical Corp.

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562 Strain gage has ultimate strain capacity of 5000 microstrain. Micro Systems Inc.

563 Photocopy unit is built into an attache case. Anken Chemical & Film Corp.

564 Portable test chamber uses liquid CO_2 to achieve fast, controlled cooling. Giannini Controls Corp.

EDITORIAL ARTICLES

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18-2 Engineering and Research Reports. Developing effective technical reports; seven most important kinds. (6 pp.)

18-3 Flame-Sprayed Coatings. Four methods of flame-spraying protective coatings; guide to material selection, design of flame-sprayed parts. (11 pp.)

18-4 Hydraulic Pumps and Motors. Method for expressing speed, pressure, and viscosity in terms of nondimensional performance coefficients. (4 pp.)

18-5 DC Motor Control—Part 4. Commonly used controller accessory devices and their functions. (8 pp.)

18-6 Zing and Snap. Two suggested new parameters to describe the response of energy systems. (1 p.)

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17-7 Radii of Gyration.* Nomograms for determining k^2 where multiple dimensions occur. (5 pp.)

16-2 Project Planning.* Firm foundation for project planning: Using charts and graphs to make accurate predictions. (5 pp.)

16-3 Wire-Rope Assemblies.* Selecting wire rope from standard types; designing assemblies. (9 pp.)

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15-3 Chemical Cleaning of Metal Parts.* Selection considerations; descriptions of chemical metal-cleaning processes. (8 pp.)

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14-3 New Roller-Chain Horsepower Ratings.* Getting the most out of the new horsepower and speed ratings proposed by chain manufacturers. (4 pp.)

14-8 Stepped Shafts and Nonuniform Beams.* Predicting deflections at any point in a stepped shaft or variable-section beam. (6 pp.)

13-2 How to Sell Ideas.* Presenting ideas to management; what sales resistance to expect. (5 pp.)

13-4 Reverted Gear Trains.* Determining the number of teeth needed to get exact ratios in a reverted gear train. (4 pp.)

12-4 Clearance in Rolling Bearings.* Calculation of probable bearing life for any amount of diametral clearance or preload. (5 pp.)

12-9 Least-Square Lines.* Techniques for assessing the statistical significance of a line drawn through a series of scattered data points. (8 pp.)

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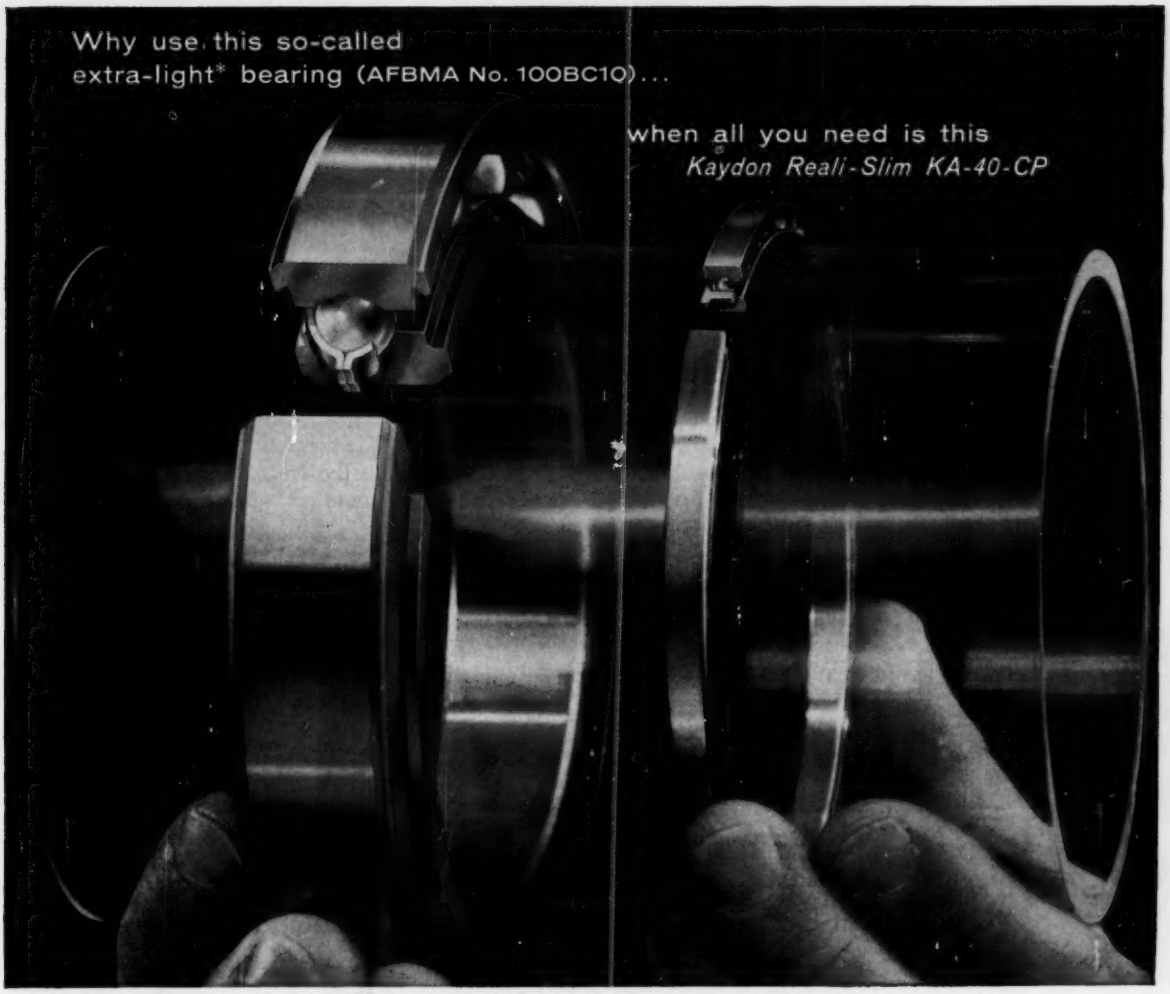
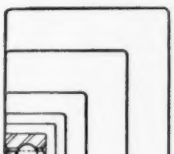


On the heels of a 500% sales increase...

Kaydon reduces Reali-Slim bearing "off-the-shelf" prices additional 24%



*Five of the six series of Type "CP" Reali-Slim bearings are smaller in cross section than the AFBMA standard "extra-light" series bearing shown above.

Due to advantages made possible by greater sales and increased production efficiency, Kaydon now passes along another price reduction on "off-the-shelf" Reali-Slim Type CP Bearings. This new price cut (up to 24%) has been made in addition to reductions up to 76% a year ago.

More than 80% of all present standard "extra-light" series bearing installations never require the full capacity of the bearing.

Kaydon now trims this expensive bearing excess! Kaydon Type "CP" Reali-Slim bearings match proper size, weight and capacity to specified shaft sizes. Overcapacity need no longer hamstring your product designs.

Here's why! In Kaydon's new Type "CP" Reali-Slim bearings (world's thinnest), width and cross section *remain the same* for all bearing sizes in any one series.

Example: each of the 15 sizes from 4" to 12" bore in the Reali-Slim KA series has only ¼" width and cross section. Result: new opportunity to save on cost, size, and weight . . . in bearings and adjacent components.

Availability? Now off-the-shelf in 90 sizes with Conrad deep-groove, ball-radial construction . . . and new bronze one-piece snap-over separator in 4" to 12" bore — ¼" to 1" width and cross section. Write for free, fact-filled "CP" bearing bulletin — with prices!

THE KAYDON ENGINEERING CORP.

•MUSKEGON, MICHIGAN

20 YEAR KAYDON PRECISION

All types of ball and roller bearings — 4" inside diameter to 178" outside diameter . . . Taper Roller Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust • Four-Point Contact Bearings

K-160R2

trends

products/processes

Atomic Waste May Help Convert Sea Water

Low-cost energy for converting salt water to fresh water may be supplied by waste fission products. The Aeronautics Div. of Chance Vought Corp. has begun work on Project Artesia and will design a test model heater capable of producing 250 gallons of fresh water per day. Concentrated radioactive wastes, reduced to powder or pellet form, are to be used as fuel to boil the salt water which will then be condensed and collected as fresh water. Economic studies by Chance Vought indicate that this method would cost $0.80 to $1.30 per thousand gallons if daily production is 1 million gallons. In the Freeport, Texas, conversion plant (where energy is supplied by natural gas), cost is $1.00 per thousand gallons.

PRESSURE-SENSITIVE GASKET is made of a metal gasket, combined with an elastomeric gasket and adhesive. Installation is accomplished by removing a release material and applying hand pressure. The product is called Teckstik and was developed by Technical Wire Products Inc., Cranford, N. J., to eliminate installation problems caused by the use of RF and fluid gasket material.

QUARTZ CRYSTAL IN A CHRONOMETER, used as the timing standard, keeps it accurate to within five seconds a year. Developed by GE's Research Laboratory, the clock uses three tunnel diodes to convert 100,000-cps crystal vibrations into a 50-cps current to drive the clock motor. It operates about four months on a flashlight-size mercury battery. Performance could be improved by constant temperature.

standards

THE METRIC THREAD is preferred over the inch screw thread in the United Kingdom—particularly in the electrical industry—if the International Standards Organization changes from Whitworth and BA threads. British manufacturers favor the metric system because they feel that ultimately it will replace Imperial and other measures.

INDUSTRY-WIDE AGREEMENT and standardization of ratiometry nomenclature and designating symbols is urged by North Atlantic Industries Inc. The company wants to organize a symposium to coincide with the 1962 IRE show; at the WESCON show, it had a two-dimensional ac vector model to provide graphical illustration of the ratiometric explanation.

computers

Tape Switch Teams Up Computers

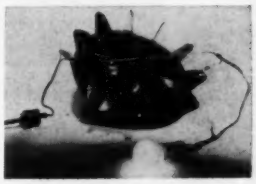
Computers and auxiliary equipment can now automatically and efficiently share reels of magnetic tape. A new switching system, developed by International Business Machines Corp., routes the tape back and forth between computers, between different channels on the same computer, or between a computer and an input/output unit. Because the device allows minimum physical handling of tape reels, it may result in fewer tape units needed in a typical computer installation.

DO-IT-ITSELF PROGRAMMING is practiced by a computer using a new system developed by the Electronic Data Processing Div. of Minneapolis-Honeywell Regulator Co. for its model 800 computer. ARGUS (Automatic Routine Generating and Updating System) reduces the human operator's work by having the computer itself perform many clerical operations. A great deal of time is saved, and the cost is half or less of that for a usual programming job.

CONTINUOUS PROCESS CONTROL of the world's largest crude-oil distillation plant will be handled by a fully automatic, or closed-loop IBM system. It will put in a 168-hour week at the Whiting, Ind., plant of American Oil Co., computing prevailing operating conditions, as well as ideal conditions, and making necessary adjustments. The system can scan 250 instruments and reset up to 24 control instruments in closed-loop control.

materials

Plastic Molding Compound Conducts Electricity



Glastic Grade X-1011-F, a new fiber-glass-reinforced molding compound, is electrically conductive for static draining. It also exhibits excellent physical strength and corrosion resistance, according to its developer, Glastic Corp., Cleveland. Suggested applications are blowers for explosion-proof equipment and components for equipment used in operating rooms, textile mills, chemical plants, mines, and printing plants. The material shows a zero Megger reading; impact strength (Izod notched) is 5 ft-lb per in.; and tensile strength is 5000 psi.

STEEL PLATE IN SPACE will be on some of the world's largest solid-fuel booster engines. Lukens Steel Co. is forming caps for these engines of ultra high-strength steel, rolled to ⅝ in. thickness. The material performs at 90 per cent of its own yield strength. Caps are 10 ft in diam, weigh 3200 lb. They go from Lukens to Excelco Developments Inc., which is building engine cases for Grand Central Rocket Co.

ECONOMY GRADE SILICON PLATE for general applications requiring Class H insulation temperatures is introduced by Westinghouse Electric Corp. H-9758 silicon plate has excellent electrical properties and high impact strength. Large glass fibers and yarns and comparatively low bond strength limit machinability, however. The material is supplied from 1/32 to 2 in. thick, in four standard plate sizes.

aero/space

New Simulator Will Duplicate Complex Aerospace Conditions

Ability to apply forces up to 20 g and to reach this force in less than two seconds will be among the accomplishments of the Dynamic Escape Simulator, recently contracted for by the Air Force. Franklin Institute laboratories will build the $1.7 million simulator, which will expose human subjects and animals to conditions in an escape capsule. Acceleration patterns encountered during launch and re-entry and complex tumbling patterns will be reproduced, and vibrations up to 15 cps will be generated. Scheduled for use early in 1963, the simulator will replace the 15-year-old Human Centrifuge at Wright-Patterson Air Force Base.

Liquid-Solid Rocket Fuel Mix Under Study

Slurry rocket fuels (mixtures of liquids and solids) will be studied by Atlantic Research Corp. under contract from the Air Force. Seeking a major increase in performance of multi-component fuels, Atlantic will work with liquid-propellant systems containing liquid oxidizers and a metallic fuel to liberate heat, in conjunction with a third material that is gas-forming.

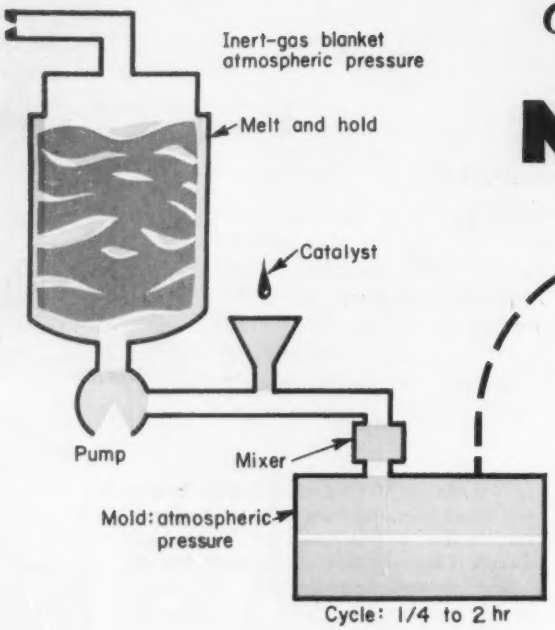
engineering/personal

A SHORTAGE OF TECHNICAL WRITERS exists and must be filled "if the business, education and research worlds are to continue to grow and benefit fully from the work of our scientists and engineers." So says Fred C. Gladeck, president of the M & T Co., Philadelphia contract engineering firm. Mr. Gladeck points out that more technical advances in science, engineering, electronics, and production-line procedures have taken place in the last 30 years than in all the rest of recorded history, and technical writing has not kept pace.

FRESHMAN ENROLLMENT of engineering students, which rose rapidly from 1950-57 (from just under 35,000 in 1950 to almost 78,000 in 1957), has been declining just as rapidly since 1958. Since—according to information supplied by the Engineering Manpower Commission of Engineers Joint Council—about 50 per cent of the students graduate, engineering graduates in 1964 should number around 34,000. About 37,800 degrees were awarded in 1961; for a comparable crop in 1965, freshman enrollment this fall must increase more than 8000, or 12 per cent.

Cast from liquid plastic . . .

NYLON PARTS GROW UP



Castings in one step . . .

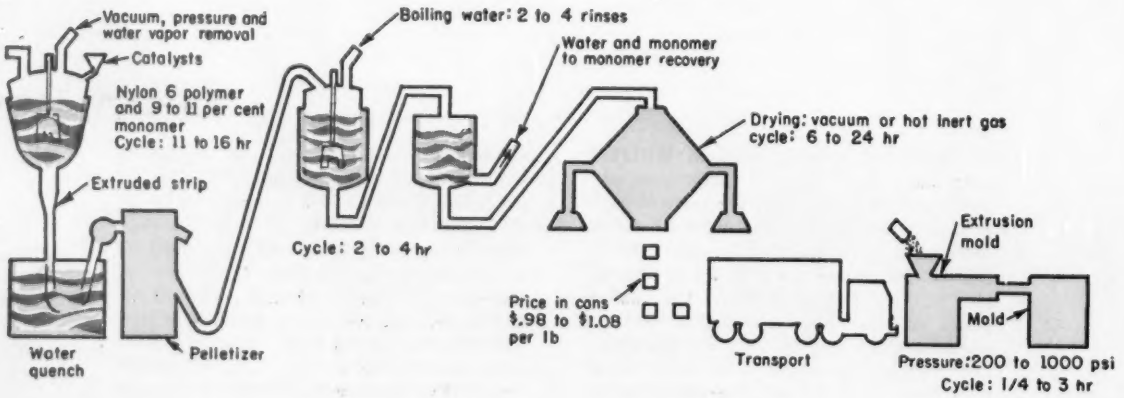
Multistep conventional operation for producing packaged nylon polymer (below) is streamlined drastically in the monomer-casting technique (above). Simplicity and flexibility of the new process permit designers of cast parts to experiment economically with distinctive nylon formulations. Direct production of parts also allows use of high filler concentrations (up to 75 per cent) for improved stability, compressive strength, and wear properties.

BY heavy-industry standards, molded-nylon parts have run to the small side, a limitation inherent in conventional "melt-pressure" methods of production. However, the design potentials of nylon may be due for drastic reappraisal. Production of massive nylon shapes is now feasible with a "monomer cast" process introduced this month by Polymer Corp., Reading, Pa. Using techniques similar to those in metal casting, the nylon-casting process converts monomeric raw material directly to finished nylon parts at atmospheric pressure.

In conventional practice, nylon is molded into finished forms and shapes from granules of polymer previously polymerized in large-scale chemical operations (sketch below). At today's prices, says Polymer Corp., conventional monomer conversion—requiring carefully controlled multistep procedures—nearly doubles the molding material cost; i.e., $0.46 per lb for the raw monomer vs. $0.98 for the packaged polymer granules.

In Polymer's monomer-casting process, five steps required in the usual method of manufacturing molding powder are eliminated (above, left). Starting with approximately one-half the raw material costs, the process obviously promises considerable savings in the final cast part.

Significant, says Polymer, is the fact that monomer casting can produce parts of "unlimited" size, free of


Vacuum, pressure and water vapor removal
Catalysts
Nylon 6 polymer and 9 to 11 per cent monomer
Cycle: 11 to 16 hr
Extruded strip
Water quench
Pelletizer
Boiling water: 2 to 4 rinses
Water and monomer to monomer recovery
Cycle: 2 to 4 hr
Drying: vacuum or hot inert gas cycle: 6 to 24 hr
Price in cons $.98 to $1.08 per lb
Transport
Extrusion mold
Mold
Pressure: 200 to 1000 psi
Cycle: 1/4 to 3 hr

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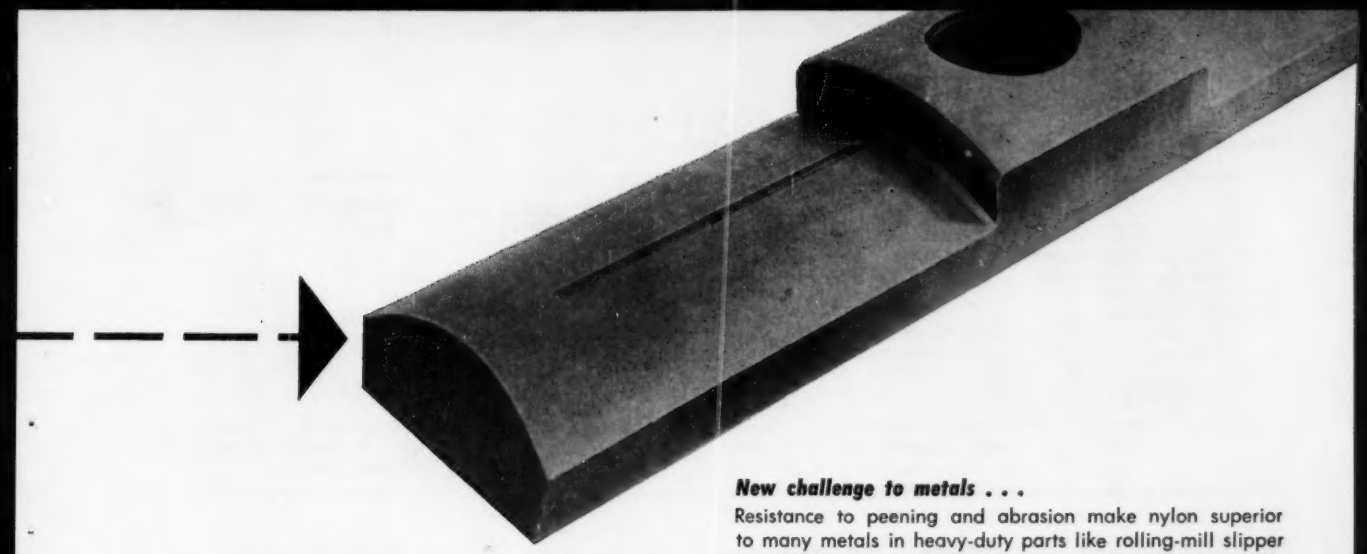


porosity. MC nylon is cast from monomer without pressure. Becoming a mobile liquid (melting point: 150 F), the monomer fills recesses of the mold, polymerizes to a solid uniformly without forming vacuum bubbles. This permits casting of shapes and complex parts with outsized dimensions.

Developers of monomer casting also point to the possibility of a major reduction in mold costs. In extrusion molding, processing pressures range from 100 to 300 psi; injection molding requires pressures to 20,000 psi. Cost of the mold could run as high as $5000 for an injection-molded part weighing only 7 lb. Tooling costs for extruding an 8-in. diam rod are approximately $1500. Polymer estimates the monomer-cast mold costs would run between $100 and $500 for the 7-lb part; a 4-ft length of 8-in. diam rod could be produced in a $100 MC mold.

Monomer casting will not, however, compete with injection molding in high-volume production of smaller parts where mold costs are small and injection cycles are as short as 15 to 30 seconds. Monomer casting would require approximately 5 minutes minimum per unit.

While techniques of nylon monomer and metal casting are similar, Polymer points to certain differences: 1. Molds for MC nylon must be nonporous because of the low viscosity of the monomer. Sand molds,

New challenge to metals . . .

Resistance to peening and abrasion make nylon superior to many metals in heavy-duty parts like rolling-mill slipper blocks (above). Polymer Corp. estimates (Table, below) for rough-cast block point up present and possible future competitive position of MC nylon with metals.

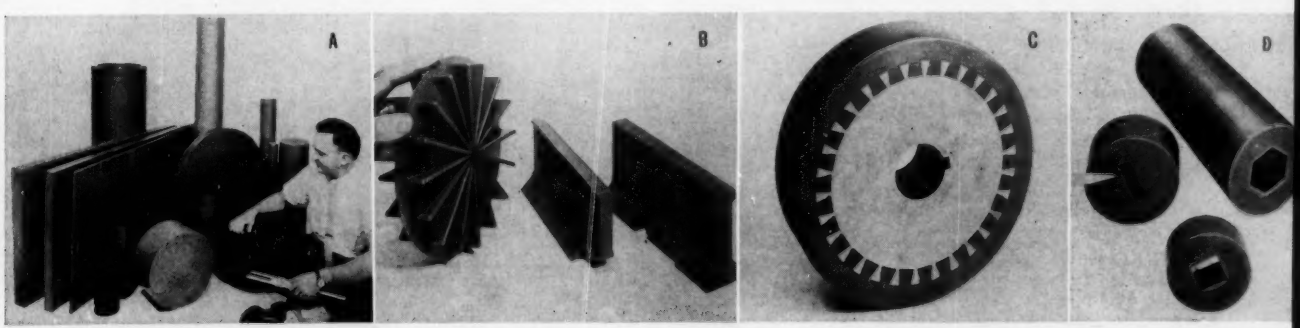
Material	Weight (lb)	Price ($/lb)	Price ($/unit)	Price (¢/cu in.)
Stainless Steel (304)	46.0	1.18	54.28	34.4
Extrusion-molded Nylon	6.5	6.70	43.70	27.7
Bronze	51.0	0.68	34.65	21.9
Yellow Brass	48.0	0.64	30.60	19.4
MC Nylon (present)	6.6	3.32	21.91	13.9
Mild Carbon Steel	46.0	0.32	14.72	9.3
MC Nylon (future)	6.6	2.00	13.20	8.4
Aluminum 40-E	14.5	0.87	12.60	8.0
Aluminum A-108	14.5	0.76	11.00	7.0
Cast Iron	42.0	0.195	8.19	5.2

Rougher competition in plastics . . .

Development of MC nylon, according to Polymer Corp., moves this high-strength plastic into price range of medium and low-cost resins (Table, below). Because of nylon's high strength, less material can often be used in a part without sacrificing performance.

General Classification	Material	Price ($ per lb)	Price (¢ per cu in.)
Premium Price Resins	Polycarbonates	1.25	5.43
	Nylon polymer	0.98	4.06
	Acetal resins	0.60	3.12
Medium and Lower Price Resins	Epoxies	0.60	2.61
	ABS polymer	0.60	2.26
	MC nylon	0.46	1.93
	Polypropylene	0.40	1.32
	Linear polyethylene	0.35	1.19

Now available in large mill shapes (A), MC nylon is a Type-6 formulation with excellent abrasive-resistance properties (impeller, B). Low tooling costs permit economical insert casting of wear-resistant surfaces (C). "As cast" parts (D) eliminate expensive machining or broaching.



Weight and part size unlimited . . .

	Injection Molding	Extrusion Molding	Extrusion	Centrifugal Casting	MC Monomer Casting
Mold Pressure Requirements (psi)	20,000	100 to 300	100 to 3000	100 to 300 g	Atmospheric
Maximum Part Weight (lb)	5 to 7	300	Not applicable	200 to 400	Unlimited
Maximum Thickness	¾ to 1½ in.	3 to 4 in.	4 in.	2 in.	Unlimited
Price per lb (dollars)	1.50 to 3.50 depending on wt, thickness, and quantity	4 to 13.00 depending on intricacy and quantity	3 to 5.00	4 to 6.00	3.00 to 5.00 currently; 1.25 to 2 ultimately
Production Rate	50 to 300 lb per hr	30 lb per hr	30 to 40 lb per hr	1 to 8-hr cycle per mold	800 lb casting in 1 hr
Limitations	Unsuitable for large parts	Low production rate	Low production rate; symmetrical shapes only	Low production rate; symmetrical parts only	Uneconomical for small parts

therefore, are ruled out. However permanent MC molds can be metal, ceramic, or glass. 2. MC nylon parts must be poured at exact temperatures, and catalysts must be carefully added. While cast-metal parts set up by heat loss, MC nylon solidifies by polymerization; process control, therefore, must be more precise.

In its initial market development, Polymer Corp. is concentrating on industrial applications where nylon's characteristics are widely accepted. The company predicts that nylon, now considered to be a premium-priced resin, will be reclassified to compete in applications now dominated by medium and low-priced resins.

Also considered prime competitive targets are metals like stainless steel, brass, and bronze. Although less rigid and providing lower tensile strength than metals, MC nylon provides excellent bearing characteristics (with or without lubrication), light weight, electrical insulation, resistance to mild acids and alkali solvents, and absorbs shocks and vibration. As an additional cost bonus, nylon can usually be machined at higher rates than metals.

For applications permitting use of symmetrical shapes in standard size ranges, MC nylon is now available in tubular bars (ODs from 2 through 15 in.; IDs from 1 through 14¼ in.). Plates (24 x 48 in.) are supplied in thicknesses from ¼ in. through 4 in. Rod diameters run from 3 to 8 in. with lengths from 6 to 24 in.

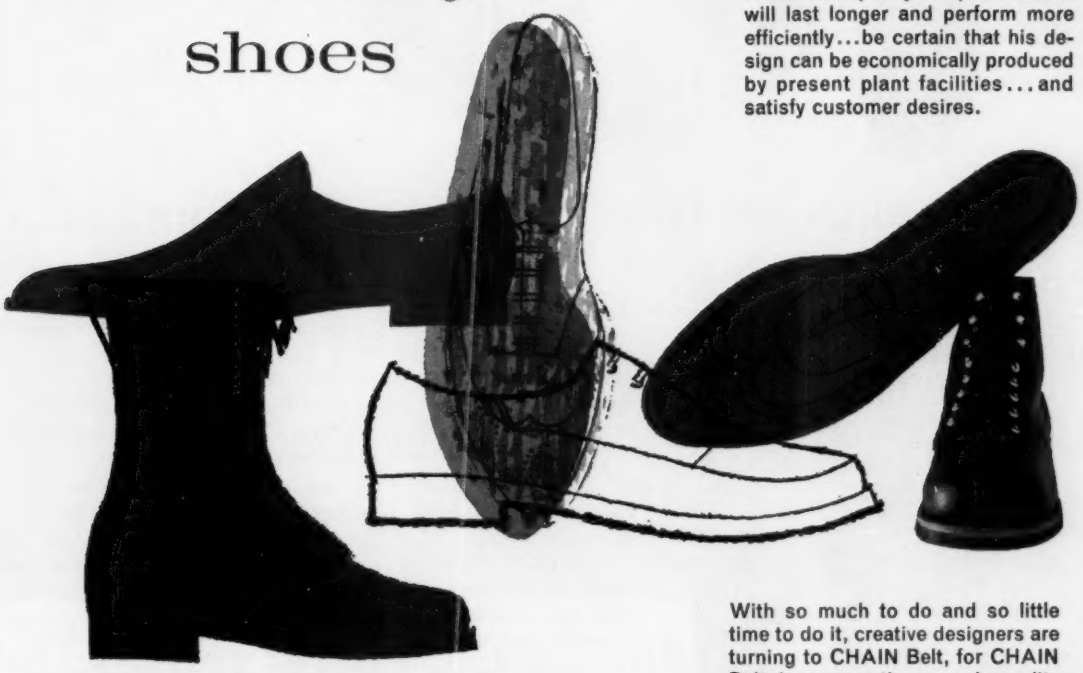
The complex-shape market, according to the company's projections, will become much larger in the future. At the present time, limited production is available for custom cast parts ranging from 1 to 100 lb.

High resistance to heat distortion . . .

Property	Test Condition	Unit	ASTM Method	Type 66 Nylon	Type 6 Nylon	MC Nylon 901
Mechanical						
Tensile Strength	73 F	psi	D638	9000-12,000	9000-12,000	11,000-14,000
Elongation	73 F	per cent	D638	25-200	25-250	20-30
Tensile Impact	73 F	ft-lb/in.^{2}		90-180	40-150	80-100
Shear Strength	73 F	psi	D732	9600	7600-8200	10,500-11,500
Modulus of Elasticity	73 F	psi	D638	400,000	350,000	350,000
Stiffness	73 F	psi	D747	200,000-400,000	230-350,000	200,000-400,000
Hardness, Rockwell	73 F		D785	R110-120	R111-R118	R-118
Deformation Under Load	122 F 2000 psi	per cent	D621	1.0-3.0	1.0-2.5	0.5-1.0
Thermal						
Heat-Distortion Temp.	264 psi	F	D648	200	130-175	400
	66 psi	F	D648	360	345-365	425
Melting Point		F	D569	496 ± 9	432 ± 9	430 (gel temp.)
Coeff. of Linear Thermal Expansion		in./in./F	D696	5.5×10^{-5}	5.0×10^{-5}	5.0×10^{-5}
Flammability		in./min	D635	Self-extinguishing	Self-extinguishing	Self-extinguishing
Electrical						
Dielectric Strength (short-time)		v/mil	D149	300-400	300-400	500-600
Dielectric Constant	60-cycles		D150	4.1	5.0-14.0	3.7
	10^3 cycles		D150	4.0	4.9-10.1	3.7
	10^6 cycles		D150	3.4	4.0-4.7	3.1
Power Factor	60 cycles		D150	0.014	0.06-0.10	0.02
	10^3 cycles		D150	0.02	0.06-0.11	0.02
	10^6 cycles		D150	0.04	0.04-0.13	0.02
Other						
Specific Gravity			D792	1.14-1.15	1.12-1.15	1.16
Water Absorption		per cent	D570	1.5	1.5-2.0	0.9
Water Absorption-Saturation		per cent	D570	7.9	8-10	5.5-6.5

TO THE CREATIVE DESIGNER...

how many shoes must you fill?



Today the design engineer must be more than a competent designer! He must wear the shoes of top management, purchasing, production, sales, service *and* the customer.

He must design for lower cost, higher profit...include more sales features...specify components that will last longer and perform more efficiently...be certain that his design can be economically produced by present plant facilities... and satisfy customer desires.

With so much to do and so little time to do it, creative designers are turning to CHAIN Belt, for CHAIN Belt does more than supply quality products. We provide unequaled service to help design engineers select and apply the proper Rex Chains, Sprockets and Couplings to satisfy his needs.

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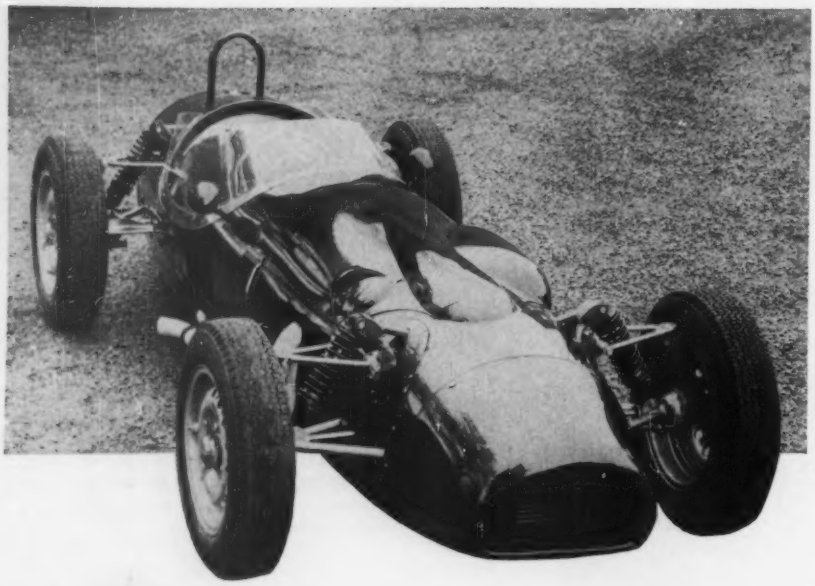
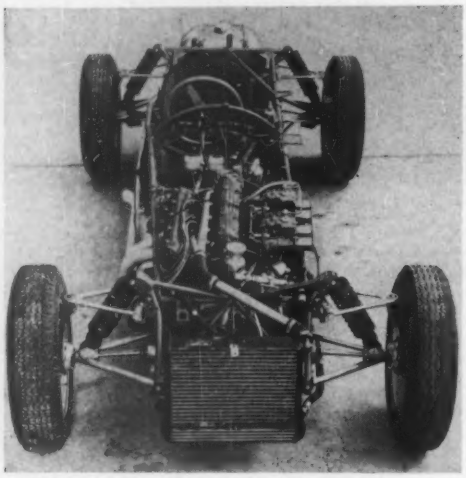


Major change in driving methods will be required for the P99. In conventional cars, fast cornering is achieved by sliding the rear wheels under power to promote a four-wheel drift. The car is held at a yaw angle all the way around the bend. The P99 may have to corner more slowly than its competition (or faster, if drifting is to be achieved). Straightaway acceleration of the car will undoubtedly be superior, and its traction, particularly on wet surfaces, should be noticeably better than two-wheel drive cars.

Four-Wheel Drive Tries a Racing-Car Comeback



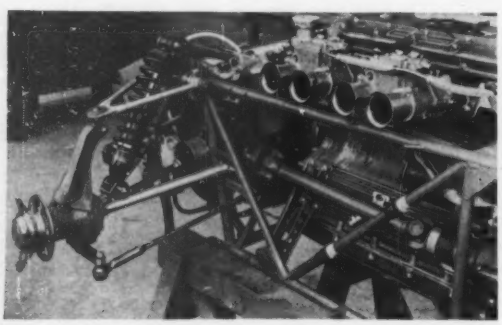
Same size tires are used all around on the P99 (above); there is equal traction and weight at each wheel. Interchangeable engines—Coventry Climax FPF 1.5 and 2.5-liter—give the car versatility. Both engines are four cylinder, have overhead camshafts. The smaller version develops 153 hp at 7500 rpm; the larger, 243 hp at 6800 rpm.

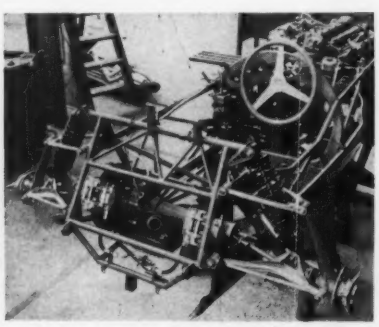
LONG-STANDING theories concerning four-wheel drive may be proved or disproved when the English designed Ferguson P99 makes its racing debut. If the car performs well and proves mechanically reliable, certain of its key engineering features—four-wheel drive and Dunlop Maxaret four-wheel brakes—may be incorporated in a line of passenger cars being designed by the Ferguson organization.

Although the P99 is by no means the first four-wheel-drive racing car to be built, it represents a considerable advance in drive-line design. Most previous versions either had over-run freewheels in the drive to the front wheels (i.e., no four-wheel drive on over-run), or used a third differential between front and rear wheels, which permitted any one wheel or pair of wheels to spin or lock.

In the Ferguson system, a unique center, or master differential, plus a rather complex "control unit" divide torque evenly among all four wheels. Details of the control unit have not been released, although its operation is known to be similar to that of present limited-slip differentials. If one or both wheels of one pair tend to spin, torque is transferred to the opposite pair until speeds are synchronized.

Ferguson's anti-skid braking system is similar to that used on aircraft. It provides completely automatic "on—off" action, as if the driver were gently pumping the brake pedal.





Front and rear differential assemblies: Constant-velocity joints are used at each end of the driveshafts; inner members of the joints are a sliding fit on their driving splines. Disc brakes are mounted inboard; hydraulic pressure is supplied by a transmission-driven pump.

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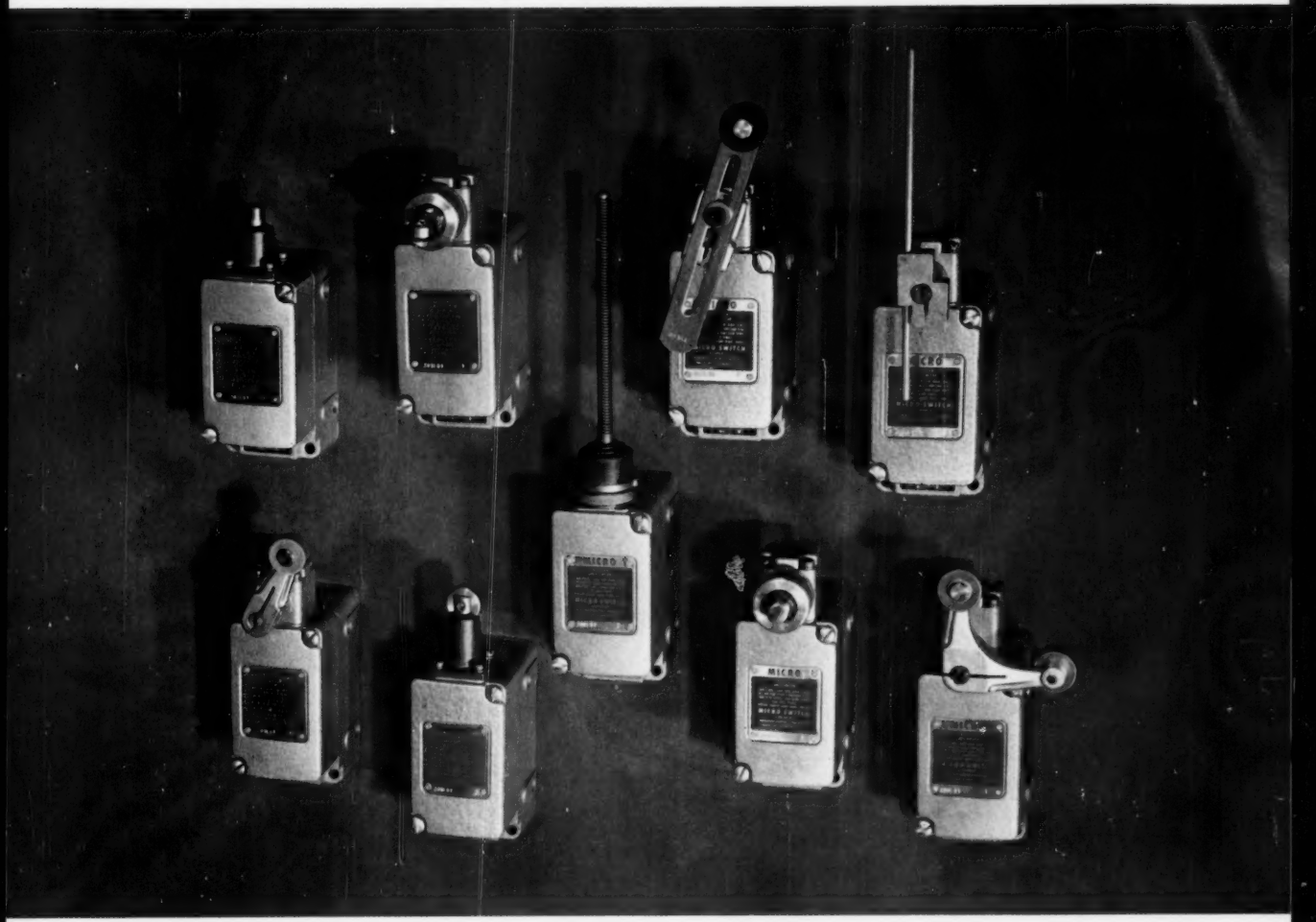

Cut downtime to 20 seconds with

MICRO SWITCH "Plug-in Limit" Switches

The terminal block, permanently mounted, has no parts to wear out. The actuator-switch assembly plugs in like a radio tube.

The oil and liquid-tight seals and the wear resistant qualities of "200LS" snap-action limit switches make them ideal for use as dependable long-life safeties, limits and interlocks in the most severe industrial applications.

Spring plugs integrally molded into the precision snap-action basic switch in the actuator assembly plug into the integrally molded terminal receptacle. Two captive screws and a ring gasket seal the two units together.

Nine standard and many special actuators are available. The basic switches are two-circuit double break. Actuator heads are adjustable to four positions and the terminal blocks may be mounted from the side or back, providing extreme versatility for changing production requirements.

For further information, see the Yellow Pages for the nearest MICRO SWITCH branch office or distributor or write for Catalog 84.

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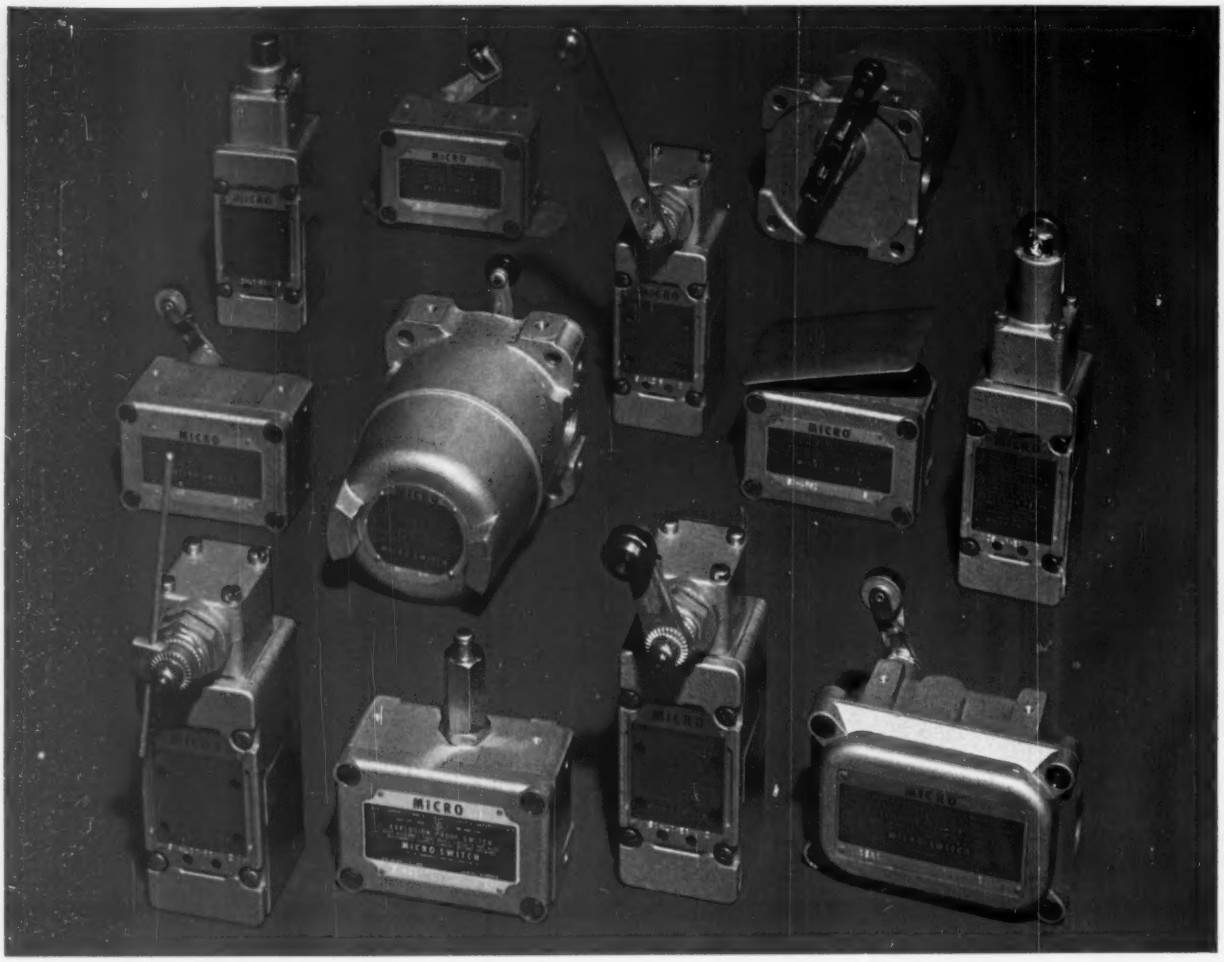
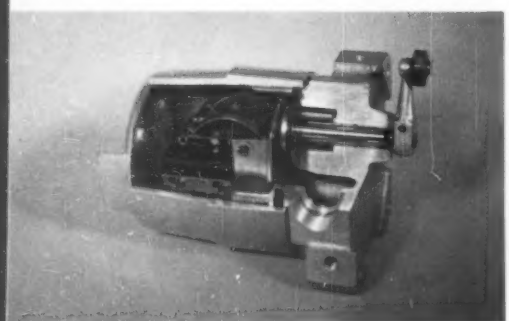
MICRO SWITCH Precision Switches

MICRO SWITCH Precision Switches



Added safety for switching in danger areas

EXPLOSION-PROOF Switches



"CX" series explosion-proof switches are rain and dust tight—valuable protection in hazardous outdoor locations. Note the two gasket seals and the accessibility for wiring to the two enclosed s.p.d.t. switching units.

MICRO SWITCH explosion-proof switches provide safe limit or interlock control functions in hazardous areas where there is danger of explosion of dust or volatile vapors. They are designed for heavy duty performance under the most severe operating conditions. The enclosed and well protected snap-action basic switching elements combine precision with long life.

All switches in this family are listed by Underwriters' Laboratories for use in hazardous atmospheres Class I, Groups C and D; Class II, Groups E, F and G. Some are also listed for Class I, Group B.

Available with a variety of actuators, circuit arrangements, electrical ratings, and operating characteristics.

See the Yellow Pages for the nearby MICRO SWITCH branch office or distributor, or write for Catalogs 83 and 84.

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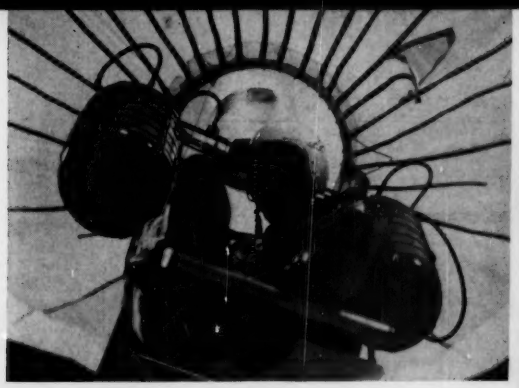
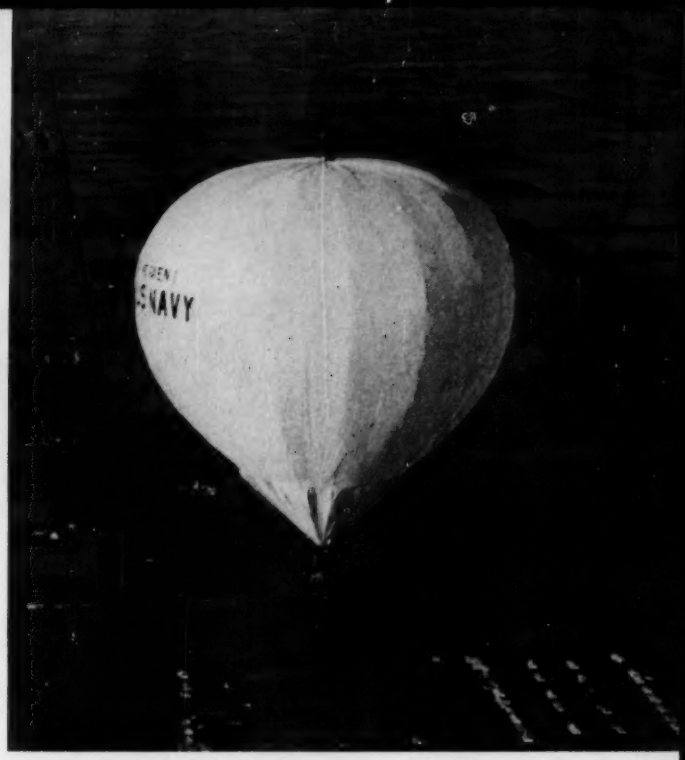
MICRO SWITCH Precision Switches





Hot-air balloon employs one very old principle and several new materials to take a man into the air. A gas-burner, the 40-ft diam Vulcoon is made of a plastic-cloth laminate with a lower section of glass cloth to withstand heat. The balloon's volume is 30,000 cu ft and it requires an average heat differential of 130 F. Tanks of gas flank the pilot; the burner is above his head. Altitude is controlled like heat on a gas stove: To go up, the pilot turns the gas up; to go down, he turns it down. The Vulcoon will carry 450 lb and can make flights of about four hours' duration. It was developed for the Office of Naval Research by Raven Industries Inc., Sioux Falls, S. D. Raven is offering a sporting model for about $3000.

Sure-footed transportation for trail blazers is the Desert Rat, which will traverse steep hills, swamps, and large rocks at speeds up to 20 mph. This mobility is provided by Terra-Tires designed by Goodyear Tire & Rubber Co. They are 16 in. in diameter and require air inflation of only 2 to 5 psi. The vehicle, built by Remote Area Transportation Corp., Santa Ana, Calif., has a four-cycle, one-cylinder gasoline engine and automatic transmission. The center-mounted steering wheel is accessible to either rider.

ENGINEERING NEWS

PICTURE REPORT

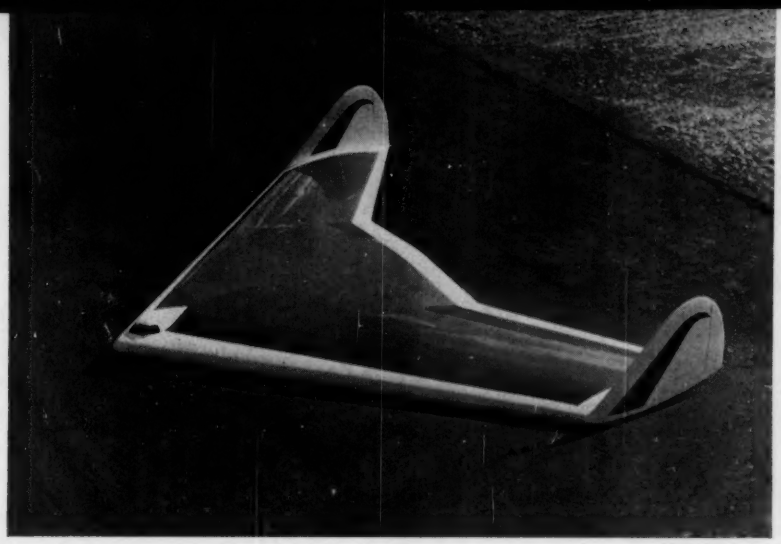
All-welded aluminum Caltex Lumba-Lumba has a cruising speed of 17½ knots. She is 77 ft long, has a beam of 17 ft, 4 in. The vessel was built for Caltex Pacific Oil Co. by Paasch Marine Service, Erie, Pa. Hull plating, superstructure, and struts are fabricated of an Alcoa aluminum alloy.

←Circle 215 on Page 19

Crop spraying by autogyro offers an efficient, simple, safe, and economical means of performing this service, according to two British firms. D. Napier & Son, aircraft engineers, and Pan Britannica Industries, crop sprayers, collaborated to develop an aerial sprayer based on the Benson autogyro. Insecticide carried in a tank behind the pilot feeds through flexible tubes to spray booms on either side of the aircraft. The developers feel that what the plane lacks in payload capabilities it makes up for in other advantages: Maneuverability at low speeds, low cost of transport to spraying site (it is hauled rather than flown), accurate, efficient coverage of irregular-shaped fields, and all-round visibility.

Multiplying and dividing electronically, without electronic components or circuitry, is accomplished by the "molecular slide rule" developed by Westinghouse researchers. The miniature mathematician, a solid slice of silicon, performs the same functions as an array of four separate diodes or three diodes and a transistor. However, it is more accurate. The block multiplies by adding voltages that are logarithms of the quantities to be multiplied. For dividing, currents are fed into the device so that logarithms of the numbers subtract. Input range is 10 to 1 and output range is 100 to 1.

Warehousekeeping gets an assist from Robotugs, electronically controlled driverless tractors which tow trailers loaded with goods. In use at Rootes Motors' main warehouse, Robotugs travel in and out of the building to transport parts to storage areas. The tractors are made by EMI Electronics Ltd., England.

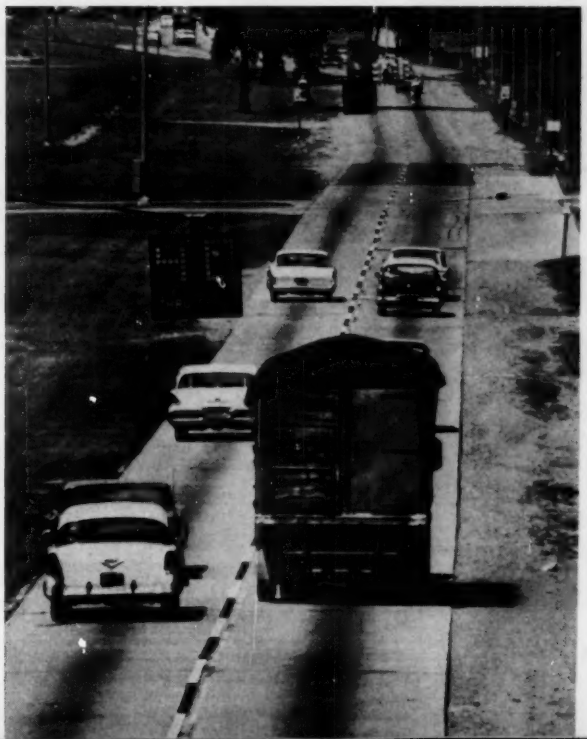


Three hundred passengers could travel across the Atlantic at a cost at least 30 per cent below present fares in this H.P. 117, according to Handley Page, Cricklewood, London, England. Cruising speed would be 550 mph, made possible by the all-wing construction and "spectacularly reduced" drag. A smooth boundary layer is to be maintained by taking in air through porous wing surfaces and expelling it so as to cause little or no wake. Handley Page has made design studies for a family of laminar-flow transports.

Sixteen powered wheels and four more to absorb shock take the Nobel-Amphibil over extremely rough terrain. The Norwegian vehicle can also travel easily through a fast-flowing stream.

ENGINEERING NEWS

PICTURE REPORT



No red lights stop the driver who heeds the advice of the Traffic Pacer. In this system, which is being tested on a four-mile stretch of Michigan road, lighted signs show the speed at which a car should be traveling to arrive at the next traffic signal while it is green. The Traffic Pacer is designed to increase—by as much as 20 per cent—a road's intersection capacity, the number of vehicles which can go through an intersection during each green cycle of a light.

Meetings and Shows

Sept. 11-14—

Society of Automotive Engineers Inc. Heavy-Duty Vehicles Meeting, including production forum and engineering display, to be held at the Milwaukee Auditorium, Milwaukee. Further information can be obtained from SAE, 485 Lexington Ave., New York 17, N. Y.

Sept. 11-15—

Instrument Society of America. Sixteenth Annual Instrument-Automation Conference and Exhibit to be held at the Biltmore Hotel and Memorial Sports Arena, Los Angeles. Further information is available from Meetings Manager, ISA, Penn Sheraton Hotel, 530 William Penn Place, Pittsburgh 19, Pa.

Sept. 13-15—

Human Factors Society. Annual Meeting to be held at Ohio State University, Columbus, Ohio. Further information can be obtained from the society's executive secretary, Dr. Paul Cheatham, Engineering Phychology Branch, Office of Naval Research, Washington 25, D. C.

Sept. 14-15—

American Society of Mechanical Engineers—American Institute of Electrical Engineers. Engineering Management Conference to be held at the Roosevelt Hotel, New York. Additional information can be obtained from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

"Claims he's designing a solar-cell motor."

Sept. 18-20—

Standards Engineers Society. Annual Meeting to be held at the Hotel Sherman, Chicago. Additional information is available from J. A. Caffiaux, executive secretary of SES, 11 W. 42nd St., New York 36, N. Y.

Sept. 24-26—

Steel Founders' Society of America. Fall Meeting to be held at the Homestead, Hot Springs, Va. Further information can be obtained from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

Sept. 24-27—

American Society of Mechanical Engineers—American Institute of Electrical Engineers. National Power Conference to be held at the St. Francis Hotel, San Francisco, Calif. Additional information can be obtained from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 24-27—

American Society of Mechanical Engineers. Petroleum Mechanical Engineering Conference to be held at the Muehlebach Hotel, Kansas City, Mo. Further information is available from ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 25-28—

Association of Iron and Steel Engineers. National Convention to be held at the Penn-Sheraton Hotel, Pittsburgh. Further information can be obtained from society headquarters, 1010 Empire Bldg., Pittsburgh 22, Pa.

Oct. 5-8—

American Society of Industrial Designers. Annual Meeting to be held at the Ambassador Hotel (Oct. 5) and the St. Catherine Hotel (Oct. 6-8), Santa Catalina Island, Calif. Additional information can be obtained from Richard M. Wilkes & Associates, 521 N. La Cienega Blvd., Los Angeles 48, Calif.

Oct. 9-11—

National Electronics Conference to be held at the International Amphitheatre, Chicago. Additional information is available from conference headquarters, 228 N. La Salle St., Chicago 1, Ill.

Oct. 9-13—

Society of Automotive Engineers Inc. National Aerospace Engineering and Manufacturing Meeting, including engineering display, to be held at the Ambassador Hotel, Los Angeles. Further information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Oct. 9-15—

American Rocket Society. Sixteenth Annual Meeting and Space Flight Report to the Nation to be held at the Coliseum, New York. Additional information can be obtained from society headquarters, 500 Fifth Ave., New York 36, N. Y.

Oct. 10-12—

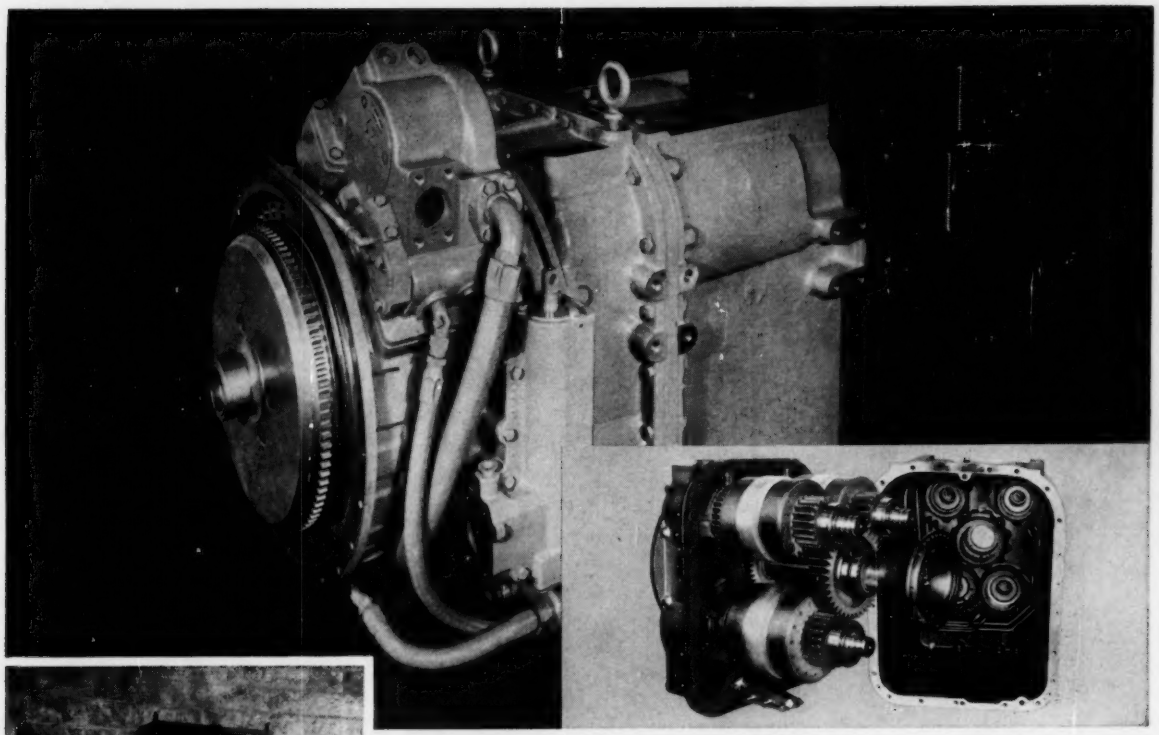
American Standards Association. Twelfth National Conference on Standards to be held at the Rice Hotel, Houston. Further information is available from ASA headquarters, 10 E. 40th St., New York 16, N. Y.

Oct. 17-19—

American Society of Mechanical Engineers—American Society of Lubrication Engineers. Joint Lubrication Conference to be held at the Morrison Hotel, Chicago. Further information is available from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

Short Courses and Symposia

Beginning Sept. 4, three series of 16 lectures—in **Plasma Physics, Environmental Engineering,** and **Space Sciences**—will be offered in locations throughout California by the University of California Extension. Plasma Physics in Theory and Application lectures will include single particle motion, statistical mechanical foundations, radiation, oscillations and waves, plasma stability, dissipative effects, plasma sources, shock wave, controlled fusion concepts, and controlled fusion status. Topics in Environmental Engineering will include test specifications and procedures, mechanical vibra-



TEST REPORT on Twin Disc's New Power-Shift Transmission

Assignment: Hauling copper ore at Arizona mine

At the open pit copper mine of Inspiration Consolidated Company, Inspiration, Arizona, 22 dump trucks work around the clock, seven days a week, to haul out 105,000 tons of ore and 75,000 tons of waste rock. As a test of vehicle endurance, this is about as grueling an operation as you could find anywhere. It was here that Twin Disc's new Series TA-51-2000 Power-Shift Transmission was asked to prove itself.

For testing purposes the transmission was installed in Truck No. 62, a 40-ton Dart 37SL Dump Truck powered with a Cummins NVH-1200 Diesel. This engine produces about 420 net hp (2100 rpm) at the flywheel.

Along with the other 21 trucks in the Inspiration fleet, Truck No. 62 was put to work on the three-mile haul road between pit and crusher.

Result: Six more transmissions ordered

In six months on the job the Twin Disc transmission proved its worth. Regarding its performance, T. M. Anderson, Open Pit Foreman for Inspiration, had this to say:

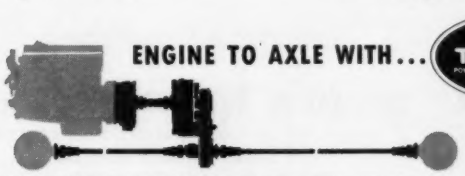
"On the basis of cycle times, fuel efficiency and shifting ease, No. 62 has been beating them all since we put in that new power-shift transmission. The truck pulls away from the loading shovel in third converter drive and is already in fifth lock-up drive when it hits the grade."

As a result of the test model's outstanding performance, Inspiration has already ordered six more Twin Disc Series TA-51-2000 Transmissions.

Twin Disc engineers will be pleased to make application recommendations for your vehicle drive.

Series TA-51-2000, designed for vehicles

- **Three models with ratio spreads of 5.45, 5.93 and 6.80.**
- **Capacities: 420 hp; 1050 lb/ft torque.**
- **Straight-through countershaft design with constant-mesh gearing.**
- **Five forward speeds; one reverse.**
- **Full power-shift in all ranges through oil-actuated clutches.**
- **Engineered as package unit with Twin Disc Single-Stage Torque Converter.**
- **Converter has lock-up clutch on front end to provide direct drive performance when desired.**
- **Hydraulic retarder saves wear on brakes . . . permits safe, controlled descents at higher speeds.**

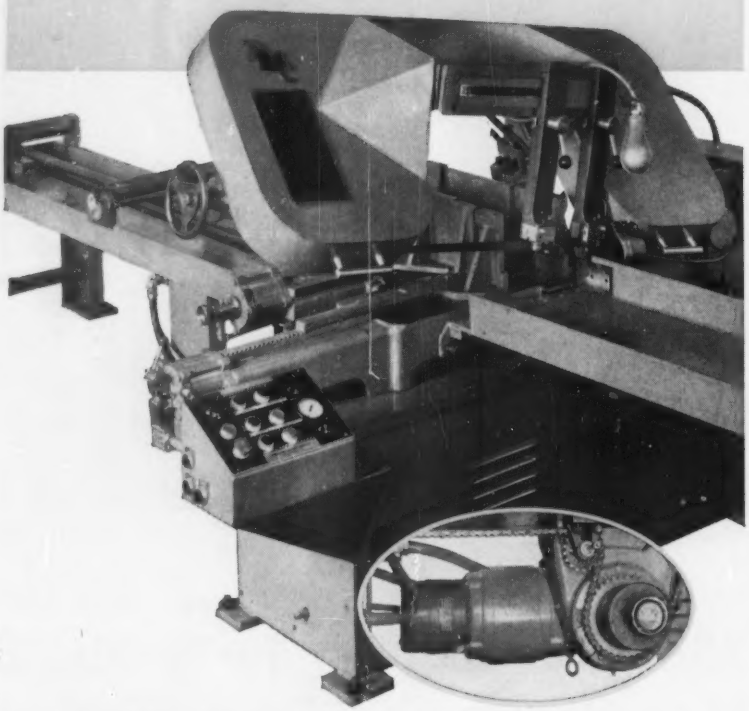


ENGINE TO AXLE WITH... TWIN DISC

TWIN DISC CLUTCH COMPANY, Racine, Wis. (Hydraulic Division) Rockford, Ill.

Circle 216 on Page 19

PEERLESS MACHINE COMPANY LETS DINGS DO IT



Guaranteed-uniform cuts at high speeds call for DINGS safe, sure stops

In automated cutting of billets, bars and structural shapes to extremely close tolerances, the conveyor must stop at precisely the right moment. That's why Peerless Machine Company relies on Dings Magnetic Disc Brakes for the fast, safe, sure stops necessary for their new automatic cycling, high-speed band saw. Operating at 14 feet per minute in forward or reverse, this machine is guaranteed by Peerless to hold length of cut to ±.003 of an inch.

Dings Brakes are *direct acting*. Movement of the braking assembly is measured in thousandths of an inch, assuring instantaneous release and fast, positive stops. There are no mechanical linkages or levers . . . consequently no worn parts to cause inaccurate or slower stops.

For *your* automated operations where fast precise braking is required, specify Dings Magnetic Disc Brakes. Call on Dings complete engineering service to help solve your specific brake problems.

Write for Bulletin BK4006

DINGS BRAKES, INC.
A SUBSIDIARY OF DINGS MAGNETIC SEPARATOR CO.
4714 West Electric Avenue
Milwaukee 46, Wisconsin

tions and testing, shock testing, dynamic measurement, low temperature and cryogenics, the spaceman and his environmental requirements, and test management and operation. Space Sciences will cover such topics as physics of the moon and sun, dynamics of outer radiation zones, geomagnetic and interplanetary magnetic fields, high energy particles, cosmic rays, solar emanation, and future space experiments. Further information on the series can be obtained from Dept. of Engineering and Sciences, University Extension, University of California, Berkeley 4, Calif.

Sept. 12-15—

Seminar for Manufacturing Engineers to be held at Pennsylvania State University. It will cover latest techniques related to automation equipment development for engineers responsible for the design, installation, and operation of such equipment. Further information can be obtained from the Conference Center, Pennsylvania State University, University Park, Pa.

Sept 20-21—

Industrial Electronics Symposium, sponsored by the American Institute of Electrical Engineers, the Professional Group on Industrial Electronics of the Institute of Radio Engineers, and the Instrument Society of America, to be held at the Bradford Hotel, Boston. Theme of the symposium will be supplier-user co-operation. Technical sessions will be on measuring techniques for industry, digital and analog techniques in industry, and new power conversion techniques. Additional information is available from D. J. LaCerda, Badger Mfg. Co., 363 Third St., Cambridge, Mass.

Sept. 27—

Seminar on Hydrostatic Transmissions, to be held at the Milwaukee School of Engineering, will be comprised of an introduction to the subject, design and analysis aspects, and typical applications. Mr. Frank Flick will speak on "Cylinder Design and Application Concepts" at a dinner following the seminar. Further information is available from Melvin E. Striegel, Director, Evening Div., Milwaukee School of

Engineering, 1025 N. Milwaukee St. Milwaukee 1, Wis.

Sept. 27-28—

Seminar on High Energy Rate Forming, sponsored by the American Society of Tool and Manufacturing Engineers, to be held at the Statler Hilton Hotel, Detroit. Topics will include tool design, part design, and development of high energy rate forming systems. Additional information can be obtained from Col. Leslie S. Fletcher, Conference Director, ASTME, 10700 Puritan Ave., Detroit 38, Mich.

Oct. 3-6—

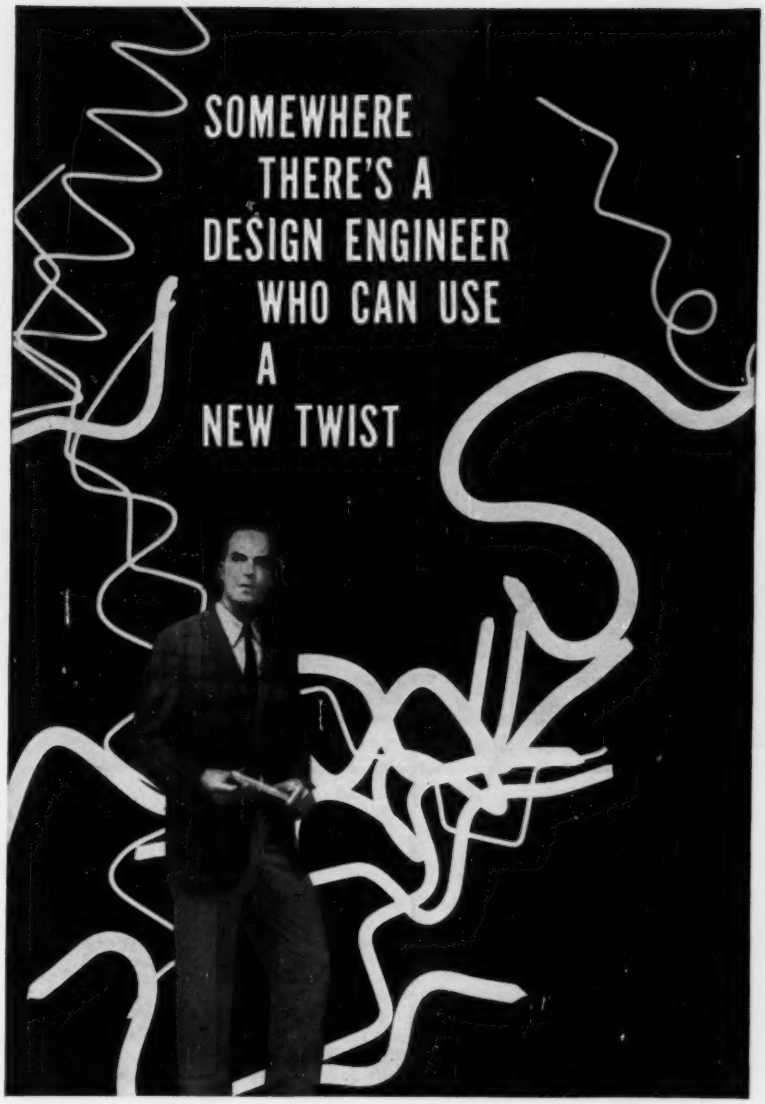
Ninth Annual Human Engineering Institute, conducted by Dunlap and Associates Inc., to be held in Stamford, Conn. The program will consist of three days of technical sessions, a half-day on management and contractual aspects of human engineering efforts, and an opportunity for private conferences. Further information is available from Dr. Jerome H. Ely, Institute Director, Dunlap and Associates Inc., 429 Atlantic St., Stamford, Conn.

Oct. 5-6—

Research and Development Administrators Workshop to be held at the University of Wisconsin. There will be three talks and a session during which problems of the group in attendance will be discussed. Topics scheduled deal with making research and development effective in company leadership, how to help R & D managers to be more effective on the job, and the development of an effective research and development department. Further information is available from the Management Institute, University of Wisconsin Extension Div., P. O. Box 2098, Madison 5, Wis.

Oct. 25-26—

Computer Applications Symposium, sponsored by Armour Research Foundation, to be held at the Morrision Hotel, Chicago. User experience in computer application and programming techniques will be emphasized. Additional information is available from Benjamin Mittman, program chairman, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.



This design engineer will possibly recognize the patterns which Audubon has created in Metalwove fabric.

And he will certainly recognize that the skill and facilities that brought these into being can create others . . . can, in fact, do almost anything with wire.

He may not put this knowledge to immediate use. But, chances are, he'll come up against a problem sometime that demands a new twist of the sort that Audubon creates. Write us for information.

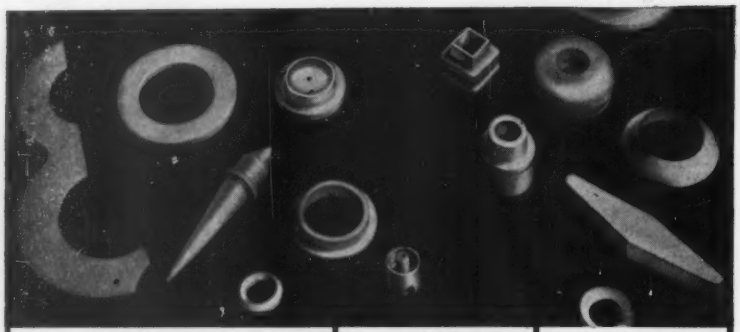
Audubon Metalwove® Belt Division

Manganese Steel Forge Co.
Richmond Street and Castor Avenue
Philadelphia 34, Pa.

See us at the Detroit Metal Show, October 23 to 27, booth 633.

Circle 218 on Page 19

PLASTICS
in Design Engineering



PROPERTY	TEFLON (TFE)	TEFLON (FEP)
Specific Gravity	2.1-2.2	2.1-2.2
Tensile Strength, 73°F	2500-3000 psi[a]	2700-3100 psi
Elongation, 73°F	100-200%	250-330%
Compressive Stress at 1% Offset	1000 psi	700 psi
Impact Strength, Izod Notched, 77°F	3.0 ft. lb./in. of notch	Does not break
Heat Distortion Temp., 66 p.s.i.	270°F	162°F
Coefficient of Linear Thermal Expansion (Approximate Values per °F)	5.5×10^{-5} in./in./°F	5.23×10^{-5} in./in./°F
Dielectric Strength, Short Time, 1/8"	400-500 v/mil[b]	400-500 v/mil[b]
Surface Arc-Resistance	700 seconds[c]	165 seconds[d]
Volume Resistivity	$>10^{15}$ ohm-cm.	2×10^{15} ohm-cm.
Dielectric Constant (60 Cycles)	2.0	2.2
Service Temperature Range (Max.)	+500°F	+400°F
Service Temperature Range (Min.)	−395°F	−395°F
Water Absorption	0.0%	0.0%
Flammability	Nonflammable	Nonflammable

(a) Tensile strength in oriented film may be as high as 15,000 psi.

(b) Value is 1000-2000 v/mil in thicknesses of 5 to 12 mils.

(c) Does not track.

(d) Samples melted in arc after 15 seconds, but did not carbon track.

This table compares the properties of Teflon* TFE and FEP. The newer FEP can be injection molded. In designing, consult your Garlock plastics specialist for best application results.

In designing intricate parts, consider the benefits of Teflon as a material.

Teflon offers a unique combination of properties unmatched by other plastics. It possesses the lowest coefficient of friction, the best non-stick characteristics, the most complete chemical resistance and the widest useable temperature range available in any plastic. Teflon eliminates lubrication, corrosion, contamination, seizing; it reduces friction, wear, space required, weight. Teflon can be used in a thousand different ways—for packings, gaskets and seals . . . for connectors, insulators, and test points . . . for valves, bearings, couplings, and insulation.

In producing intricate Teflon parts, consider the benefits of Garlock as a supplier. From virgin powder to finished piece, Garlock closely controls each step in the process to assure that the final part performs to your expectations. Complete facilities are at your disposal for molding, extruding, and machining of Teflon. If your application calls for special properties, Garlock will compound Teflon with selected fillers to greatly extend its service range. If you need unusually large configurations, Garlock will fusion-weld Teflon . . . the weld will have the same thermal, chemical and electrical properties as the Teflon itself.

Parts made from Nylon, Delrin*, C.T.F.E., Lexan† are also available from Garlock. Let your local Garlock representative quote on your design, or ask his assistance on any design problems concerning materials and applications. Call him at the nearest of the 26 Garlock sales offices throughout the U.S. and Canada. Or, write for Catalog AD-177. Garlock Inc., Palmyra, N.Y.

GARLOCK

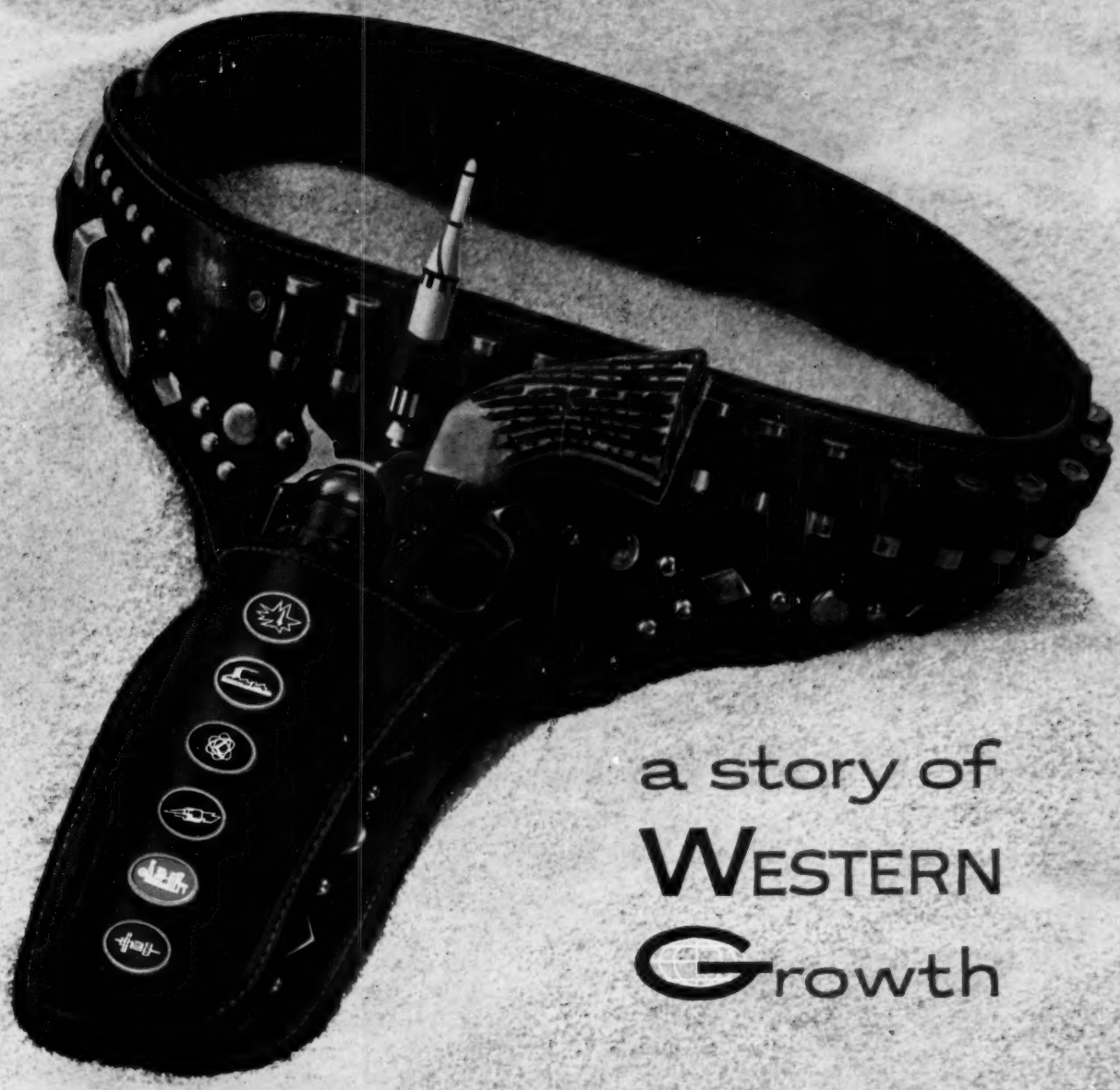
Canadian Div.: Garlock of Canada Ltd.

Plastics Div.: United States Gasket Company

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

*DuPont Trademark
†General Electric Trademark

Circle 219 on Page 19



a story of WESTERN Growth

The early West needed machinery to help it grow—and Western Gear Corporation, a driving force in expansion of the West since 1888, supplied a good share of vital power transmission products. ■ Today, matching the growth aims of American industry, Western is far more than a maker of gears—it is a supplier to the entire Western World. WG today stands for Western Growth—an organization that specializes in making *other* companies grow—*other* projects succeed. ■ This is the time to look into the performance record of Western's six divisions and WG's proven capabilities . . . as engineers, designers and manufacturers, of components, systems and all types of electro-mechanical equipment, serving industry and the military in all applications of power and motion. ■ Western Growth can be the instrument of *your* growth. It will pay you to investigate. Address Executive Offices, Western Gear Corporation, P.O. Box 182, Lynwood, California.

WG

SYSTEMS MANAGEMENT DIVISION

INDUSTRIAL PRODUCTS DIVISION

PRECISION PRODUCTS DIVISION

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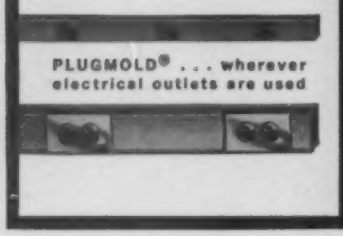
GRAPHIC ARTS DIVISION

SOUTH-WESTERN DIVISION

WESTERN GEAR CORPORATION

SEATTLE, WASHINGTON; BELMONT, LYNWOOD, PASADENA, CALIFORNIA; HOUSTON, TEXAS. OFFICES IN ALL PRINCIPAL CITIES.

Circle 220 on Page 19



WIREMOLD®
ideas

THE WIREMOLD COMPANY · HARTFORD 10, CONN.

Versatile equipment studded with outlets

Plugmold built into electronic racks makes power accessible wherever it may be used

Typical of original equipment that needs available outlets, amplifier and power supply racks for large sound systems have added versatility with Plugmold. These multi-outlet assemblies allow almost unlimited possibilities for outlet arrangements.

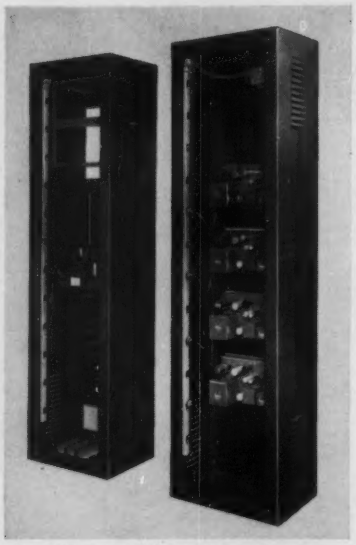
Almost any arrangement of Plugmold can be accomplished: a single strip (far right), parallel runs (center), mounted horizontally, vertically, around corners, or in any fashion to match configurations of equipment. In both of these applications, factory wired sections were used, with duplex outlets spaced 6" on centers. Other standard outlet spacings, with duplex or grounding outlets, 2-wire or 3-wire, are also available. Other Plugmold types permit you to place many other kinds of devices in any position desired. For example, fuses, circuit breakers, multi-prong jacks, etc., can be installed in the raceway. Or, portable power strips can be made with provision for easy connect and disconnect.

On your work bench too

Designers often use electrical/electronic equipment in their work. Plugmold is an ideal way to wire your work bench with all the outlets you need — the ultimate in convenient efficiency.

Standard Plugmold types are stocked by electrical wholesalers everywhere. Wiremold welcomes the chance to assist in developing special assemblies.

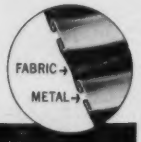
At left, two rows of Plugmold provide outlets on electronic rack. At right, technicians' work benches have convenience outlets for equipment.



Plugmold outlet strips make a neat power source in back of amplifier and power supply racks.

Flexible duct resists abrasion—

Even exhausts diamond dust

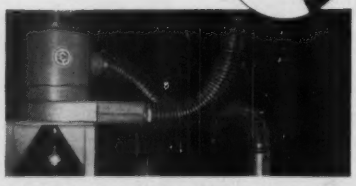


Wiremold's Type 8R duct combines the benefits of flexibility with rugged resistance to abrasion.

Designed to handle such abrasives as diamond dust, glass cuttings, wood chips, pulverized or granular materials, the duct is made of Nylon fabric coated with heavy, abrasion resistant neoprene. This fabric locks mechanically to a flat metal spiral (see cutaway) making the duct firm and rugged, yet completely flexible.

The duct can be assembled and secured in seconds. Fasten it to connector by securing 2 or 3 drill screws through the flat spiral and connector.

Six standard duct types cover a wide range of uses. Special shapes (e.g., square, oval) can also be furnished.



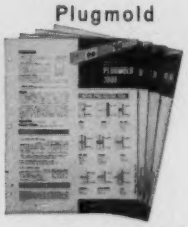
Exhaust duct on diamond dust collector. Cutaway shows duct's unique mechanical locking construction.

SEND FOR LITERATURE

Air Duct

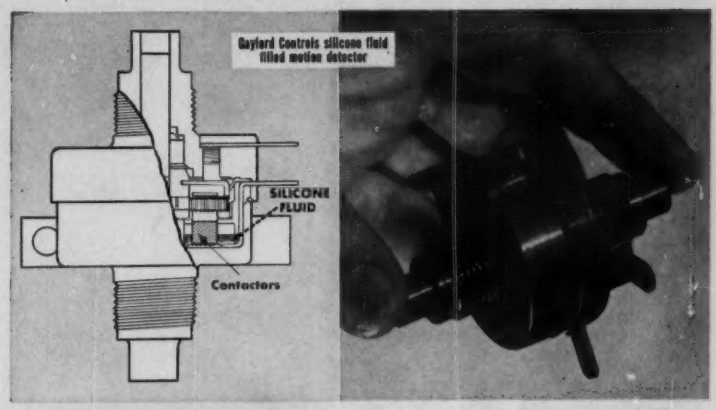
For Air Duct data, Circle 221 on Page 19

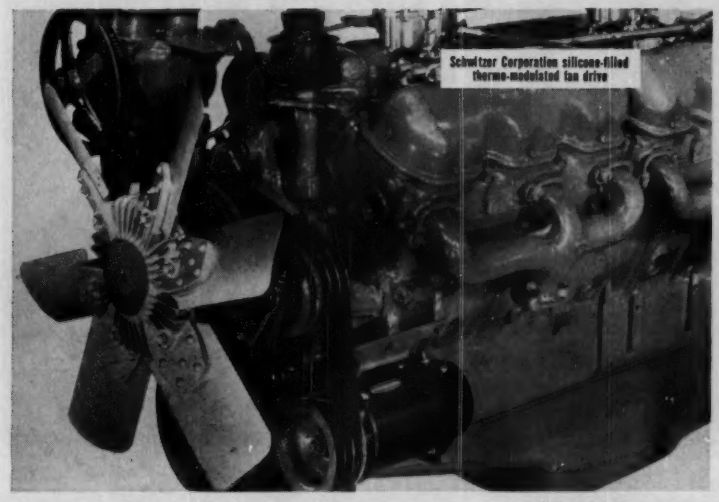
Plugmold

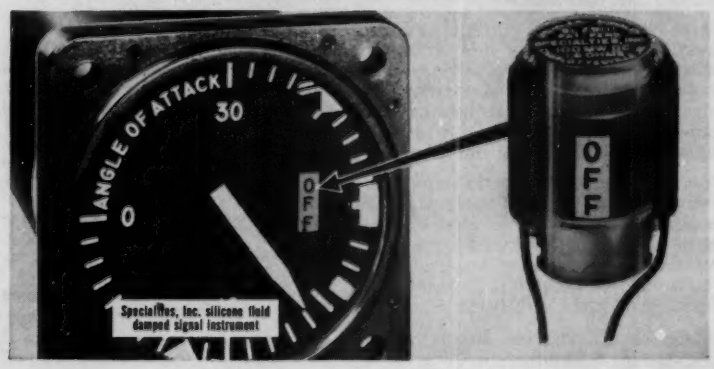


For Plugmold data, Circle 222 on Page 19

Dividend for designers



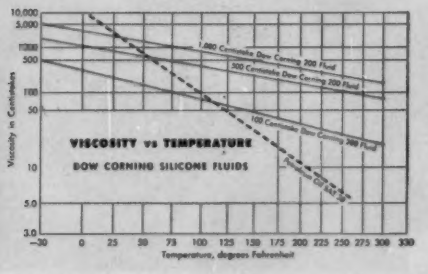




How to make your designs more versatile

Even the best device can be made more versatile, more practical, more efficient by engineering it to utilize the advantages of Dow Corning silicone fluids. Here's what these advanced engineering materials have to offer designers.

Stability to Heat, Cold. Dow Corning silicone fluids retain near-constant viscosity over wide temperature spans — help assure uniform, dependable performance in spite of temperature fluctuations. Damping effect, for example, only decreases from 3 to 1 over a temperature rise from minus 40 to plus 160 F. Under identical conditions, damping effect of a petroleum fluid decreased from 2500 to 1.



Long Life. Highly resistant to oxidation, Dow Corning silicone fluids undergo virtually no change even after long term service — are nonsludging, nongumming. Silicone fluids are inert . . . will neither corrode metals nor cause rubber to swell . . . have no harmful effect on component parts of devices or systems.

Good Compressibility. For liquid springs, shock absorbers and similar equipment, Dow Corning produces special silicone fluids that offer unusual compressibility in addition to all the other desirable properties that characterize silicone fluids. These compressible fluids make possible reductions up to 30% in oil chamber size . . . save vital weight and space.

For detailed information and technical assistance in adapting silicones to your products, address Dept. 6920a, Dow Corning Corporation, Midland, Michigan.

first in silicones

Dow Corning

Circle 223 on Page 19

INTRODUCING INDUSTRY'S MOST COMPACT
60-HP HEAVY-DUTY AIR-COOLED ENGINE
• 4-cycle 4-cylinder V-type
• 36 hp at 1400 rpm to 60.5 hp at 3000 rpm
• 154 cu. in. displacement
• 7.1:1 compression ratio
• weighs only 521 pounds dry
NEW 60 HP. WISCONSIN MODEL V-460D WITH VALVE-IN-HEAD DESIGN!

Now Wisconsin offers you more power . . . amazing compactness . . . greater efficiency and economy . . . and simplified upkeep.

At 60 hp, the new V-460D is the most powerful V-4 in the Wisconsin line. It's precision-built for all-weather dependability and long life in severe applications. And it's designed to boost the customer appeal of the power equipment you build.

You can cut design and production costs, because this 521-pound compact requires less structural support. You can up the payload and work capacity of your equipment — make it lighter and easier to handle — and more economical for users to own, operate and maintain.

Valve-in-head design and higher compression afford greater fuel economy with *regular* gasoline. They provide cooler and more efficient engine performance—and simplify upkeep. Even removing a cylinder for piston or ring replacement takes only minutes.

Check all the benefits and savings the V-460D offers you and users of your mechanized equipment. Better still, let us tailor it for your self-propelled, portable, or stationary applications. For more information, get Bulletin S-282. Write to Dept. 0-11.

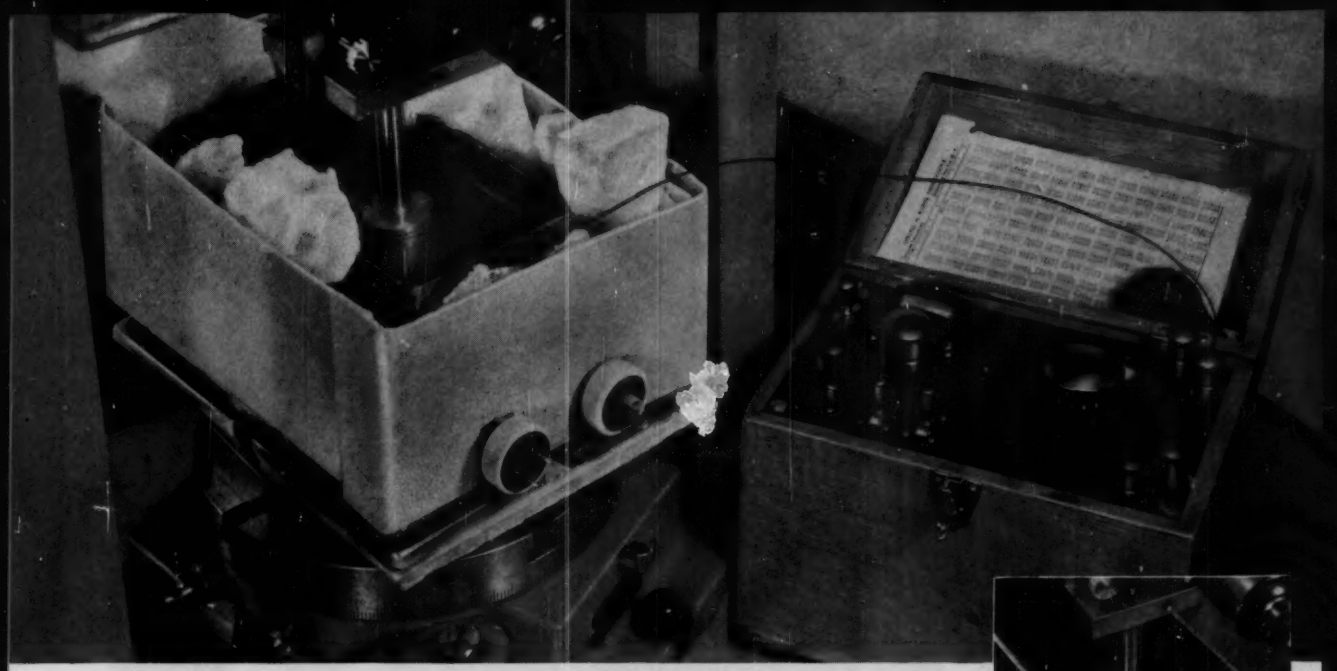
CHECK THESE FEATURES:

- **Center main roller bearing and tapered roller end main bearings to absorb all thrusts.**
- **Stellite-faced exhaust valves and positive rotators for up to 500% longer valve life.**
- **Controlled pressurized lubrication for full-time oiling to all working parts.**
- **Automatic protection against overheating and servicing neglect.**
- **12-volt electric starter with distributor ignition.**
- **Wide range of optional equipment and accessories.**

See the V-460D at Booth No. 154, at the SAE Engineering Display, September 11 through 14, 1961, Milwaukee Auditorium.

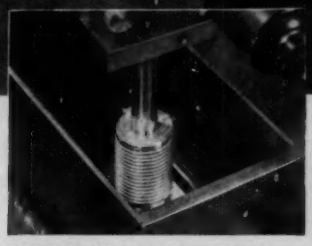
WISCONSIN MOTOR CORPORATION
MILWAUKEE 46, WISCONSIN
World's Largest Builders of Heavy-Duty Air-Cooled Engines

0-338



Spring RELIABILITY measured to less than 0.1%

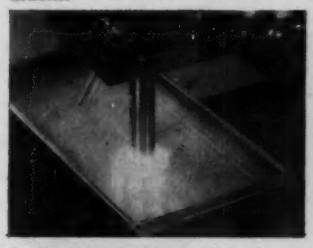
at temperatures from -85°F to 185°F



Altimeter instrument spring is secured in tank fixture ready for testing under simulated operating conditions.

WHAT TYPE OF PRODUCT REQUIRES SUCH SPRING ACCURACY?

The heart of a precision aircraft altimeter contains a diaphragm and a single torsion spring. Specifications of the spring call for the rate to be constant within 0.1% over the entire deflection range and at all temperatures between −85°F and 185°F; hysteresis must be below 0.03%; and no measurable creep can be tolerated in 72 hours at maximum deflection and maximum test temperature.



Spring is rotated in hot or sub-zero liquid and its torque balanced against a calibrated wire.

HOW PROOF OF ACCURACY WAS DETERMINED

Because no equipment was commercially available to measure torsion springs to this extreme accuracy, A.S.C. Research and Development Center shared with the customer the cost of developing a special tester. Each spring is rotated in hot and cold liquid while its torque is balanced against a precision torque wire. Sightings of deflection through a transit, connected with the torque wire, are made on a scale mounted 14 feet distant. Data obtained from this unique apparatus give the spring user proof that each lot of springs falls safely within his ultra-precise limits.

Subsequently, the equipment has been used to calibrate several other torsion springs with ultra-precise specifications.

While your springs and spring-like parts may not require such precision, here is ample assurance that A.S.C. can make *your* springs with predictable performance in the degree desired.

May we discuss your needs?

Minute changes in deflection are read through a transit on a scale 14 feet distant.

6108

Broad treatment of the subject of spring reliability is contained in a recent issue of A.S.C.'s house organ, *The Mainspring*. Send for your copy.

Associated Spring Corporation

General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
F. N. Manross and Sons Division, Bristol, Conn.
Dunbar Brothers Division, Bristol, Conn.
Wallace Barnes Steel Division, Bristol, Conn.
Merchandise Division, Corry, Penna.
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Milwaukee Division, Milwaukee, Wis.
Seaboard Pacific Division, Gardena, Calif.
Wallace Barnes Co., Ltd., Hamilton, Ont. and Montreal, Que.

Circle 225 on Page 19

GN

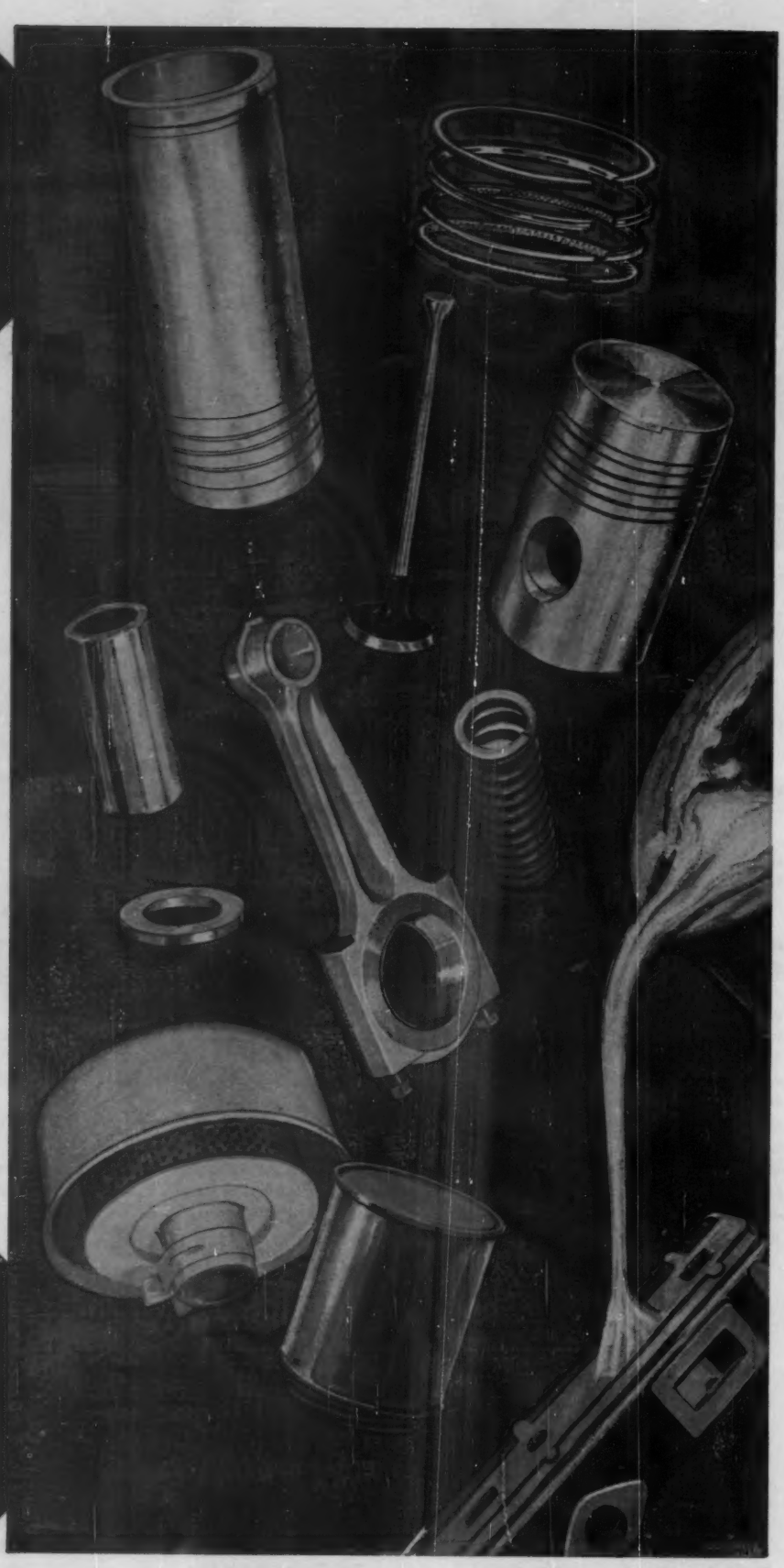
Pedrick

SUPERIOR

WHITE
MACHINE WORKS

BURD
GRAF FLEX

GE



GN

Nation's largest manufacturer of heavy-duty and specialized engine parts—

NEW GOULD-NATIONAL ENGINE PARTS DIVISION

In creating its new Engine Parts Division, Gould-National combined under one corporate roof the brands, products, services and facilities of these wholly-owned subsidiaries:

Wilkening Manufacturing Co., Philadelphia, manufacturers of Pedrick® piston rings and castings.

White Machine Works, Eau Claire, Wisconsin, manufacturers of Superior-Arrowhead cylinder sleeves, sleeve assemblies, pistons, piston pins, Burd piston rings, valves and valve train parts, foreign car engine parts and filters.

Gillett & Eaton, Lake City, Minnesota, piston and casting specialists of cast iron, aluminum alloy, Vanasil® aluminum alloy pistons and specialized engine parts.

Arrow Head Steel Products, Howell, Michigan, manufacturers of aluminum pistons, connecting rods and other castings.

Now, Gould-National, the nation's largest producer of automotive replacement batteries, is also the nation's largest basic manufacturer of heavy-duty and specialized engine parts. The Division is the largest one stop source for the most complete line of engine parts available from one manufacturer. It is the only engine parts manufacturer with both iron and aluminum casting and machining facilities.

By utilizing the efforts of one combined sales force, the customer will benefit from greater sales-service efficiency, more concentrated field coverage.

Product improvement will result from the formation of a special team in the Gould-National Engineering and Research staff. It is the Gould-National way of assuring continuing top quality and improved product performance.

New engineering developments, manufacturing and production techniques from all areas within the Division will benefit all customers, no matter what the product may be.

This is the Gould-National Engine Parts Division—the nation's newest parts manufacturing group with over two centuries of combined experience.

Need heavy-duty engine parts? Automotive engine parts? Foreign car engine parts? Parts for such specialized applications as air and refrigeration compressors? Need complete and modern facilities for aluminum and iron castings? If your specifications call for the best of these, if you need them fast and need them right . . . turn to . . .

Superior-Arrowhead and Burd are trademarks of Gould-National Batteries, Inc.

GN

ENGINE PARTS DIVISION
GOULD-NATIONAL BATTERIES, INC.
St. Paul 1, Minnesota

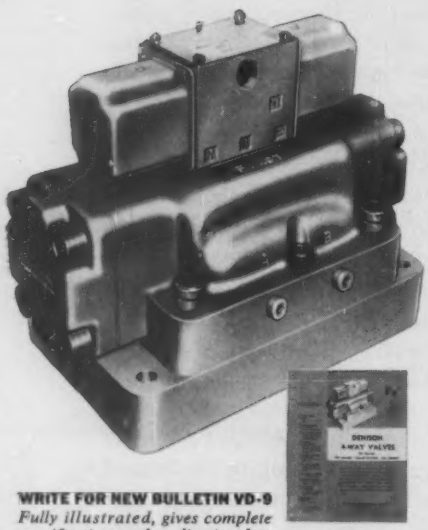
Circle 226 on Page 19

Denison and Denison HydrOILics are registered trademarks of Denison Eng. Div., ABSCO

DENISON HydrOILics

Get 7 important advantages for smooth directional control with these **NEW** 1½" 5000 psi hydraulic...

4-WAY VALVES



WRITE FOR NEW BULLETIN VD-9
Fully illustrated, gives complete specifications and application data for Denison's new 1½-inch 4-way hydraulic valves.

Save space, time and cost on exacting directional hydraulic applications. You can apply shockless, positive directional control to any hydraulic circuit—*by specifying Denison 4-Way Valves.* Stem-operated, pilot-operated, and solenoid-controlled for systems up to 5000 psi, these service-proved valves offer these important features for reliability and design versatility—

Shorter solenoid power stroke permits shorter over-all valve length to speed response. Denison valves deliver fast, rapid-cycle control of flows of 120 gpm.

Drawn steel solenoid covers are secured to body with internal retaining cords. No bulky chains.

Built-in check valve provides pilot pressure without addition of another valve to the system.

Adjustable pilot chokes assure smooth valving action.

Subplate, flange or threaded bodies to suit any type of installation.

Optional lever assembly converts stem-operated valves to manual operation.

Wide choice of spool types and positioning allows handling an unlimited range of applications.

Denison 4-Way Valves also feature large 1½" capacity porting • ample wiring space • interchangeable parts • built to JIC standards.

Contact your nearby Denison hydraulic field specialist for details, or write direct to—

DENISON ENGINEERING DIVISION
American Brake Shoe Co.
1240 Dublin Road • Columbus 16, Ohio

HYDRAULIC PRESSES
PUMPS • MOTORS • CONTROLS

DENISON
HYDRAULIC POWER

Circle 227 on Page 19

DIMENSIONS FOR CROWN-TYPE HRH GEARS

For a gear outside diameter of unity and 90° shaft angle.

Ratio	Ra	10⅓	12⅓	14⅓	17⅓	21⅓	25⅓	31⅓	38	47	58	71	87	106
Number of Pinion Teeth	n	4	4	3	3	2	2	2	1	1	1	1	1	1
Number of Gear Teeth	N	41	49	44	52	43	51	63	38	47	58	71	87	106
Offset	E	0.20000	0.20000	0.25000	0.25000	0.30000	0.30000	0.33333	0.33333	0.33333	0.33333	0.33333	0.33333	0.33333
Whole Depth	ht	0.03595	0.02859	0.03547	0.02880	0.03888	0.03200	0.02738	0.04480	0.03556	0.02827	0.02293	0.01849	0.01511
Gear Outside Diameter	D_{go}	1.00000												
Gear Crown Distance	X_c	0.06800	0.06299	0.07920	0.07800	0.06928	0.06832	0.06809	0.06027	0.06080	0.06720	0.06969	0.07004	0.07182
Gear Face Width	F	0.13003	0.13003	0.13000	0.13000	0.13008	0.13006	0.12996	0.12996	0.12996	0.12996	0.12996	0.11502	0.09440
Pinion Outside Diameter	D_{po}	0.23968	0.21621	0.22107	0.20667	0.20668	0.19296	0.18400	0.19929	0.18400	0.18400	0.17938	0.17244	0.16996
Pinion Inner Crown Distance	Bi	0.29429	0.29792	0.25413	0.25613	0.19344	0.19648	0.13849	0.13849	0.13849	0.13849	0.13849	0.17031	0.20924
Pinion Outer Crown Distance	Bo	0.48672	0.48363	0.47067	0.46707	0.44944	0.44480	0.42222	0.43289	0.42667	0.42276	0.41867	0.41422	0.41102
Minimum Pinion Mounting Distance	BM	0.52597	0.51392	0.50013	0.49040	0.47360	0.46448	0.43644	0.45511	0.44391	0.43644	0.42951	0.42347	0.41884
Gear Spiral Angle (Deg.)	Ψ	41.45	45.00	37.69	40.83	32.03	34.55	29.42	30.56	32.49	34.00	35.16	37.39	39.71
Pinion Spiral Angle (Deg.)	Ψ_p	68.82	72.37	72.77	75.91	75.63	78.15	79.44	80.58	82.51	84.02	85.18	86.26	87.11
Pressure Angles Degrees	Φ_1	10												
	Φ_2	30												

If you're after a quieter transmission, or one that's more compact or flexible, it will pay you to look into our High Reduction Hypoids.

The set shown here, for example, gives a reduction of 300 to 1. The action is quiet, smooth and continuous. Because of the high pinion spiral angle you get overlapping tooth action with just one pinion tooth.

You can go to ratios as high as 360 to 1, yet stay within tight space limits. That's because the high-offset principle permits a more compact and flexible unit than the corresponding worm and wheel.

SIMPLIFIED DESIGN PROCEDURE—The above table shows one system for obtaining HRH gear dimensions—quickly and easily. To establish approximate details of your particular HRH pair—just select values from the table and multiply them by the gear diameter in inches. For ratios not listed in the tables, interpolation between columns gives dimensions accurate enough for layout purposes.

You get the full technical assistance, of course, of our engineering services when you design with these gears. We work with you on the practical design aspects and make prototypes. Then we furnish both machines and tooling for the desired production rate—*without royalties.*

Send along a set of prints of your design and we will be glad to make recommendations on how to make the gears at the lowest possible cost.

**Trademark for Gleason High Reduction Hypoids*

GLEASON WORKS

1000 UNIVERSITY AVE., ROCHESTER, NEW YORK

Circle 228 on Page 19

LOOKING FOR HIGHER EFFICIENCY AND LONGER LIFE IN RIGHT ANGLE DRIVES?

Then take a closer look at Philadelphia Spiral Bevel Reducers. They'll give you an efficiency advantage of 5 to 50% over other types of right angle drives . . . depending upon ratios.

HIGH EFFICIENCY. With efficiencies of 95 to 98%, spiral bevel reducers will lower your power costs . . . reduce the cost of prime movers.

HEAVY DUTY. The bearings and shafting in Philadelphia Spiral Bevel Reducers are designed for 185% overload. Spiral Bevel Gears and Pinions are hardened after they are cut, then lapped to a mirror finish. Helical gearing in multiple reduction units is precision hobbed and shaved from through-hardened alloy steel. Result: greater load carrying capacity, longer life.

COOLER RUNNING. Compared to other types of right angle drives, Philadelphia Spiral Bevel Reducers run cooler. Separate cooling systems are not needed for most applications.

COMPLETE LINE. Philadelphia Gear offers the most comprehensive line of Spiral Bevel Reducers available — or we can build specially engineered units to meet any special requirement. Ratios from 1:1 to 238:1. Single, double or triple reductions in either vertical or horizontal types. Catalog SB-60 gives full selection data. Write on your company letterhead for your copy.

philadelphia gear drives

PHILADELPHIA GEAR CORPORATION
King of Prussia (Suburban Philadelphia), Pennsylvania

Circle 229 on Page 19

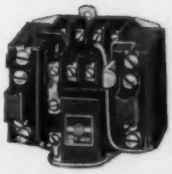
Circle 230 on Page 19→

You cannot afford to ignore the New Allen-Bradley BULLETIN 709 Starter Line

They OUTPERFORM and OUTLAST ALL Others

These new Allen-Bradley starters bring you the greatest advance in reliability and life in all motor control history. Also, they possess a compactness that's almost unbelievable—especially in the higher ratings.

The new Bulletin 709 solenoid starters feature a patented, high-efficiency magnet, which is cushioned to reduce shock and wear. Contacts are of weld-resistant cadmium oxide silver. All coils are "pressure molded" for protection against physical damage and destructive atmospheres. The two or three solderpot overload relays are trip-free and tamperproof. Brooks Stevens, famous industrial designer, has given the new enclosures a styling that adds "eye appeal" to every installation. To get full details, contained in Publication 6100, please write today to: Allen-Bradley Co., 1316 S. Second Street, Milwaukee 4, Wisconsin.



SIZE 00 NOW AVAILABLE

Provides the same long life and reliability as others in the Bulletin 709 family. Rated 1½ HP, 220 V; 2 HP, 440-550 V.

15-61-MR

ALLEN-BRADLEY

Member of NEMA

QUALITY MOTOR CONTROL

Here Your Motor Starter Dollar Buys

MORE OF THE QUALITIES YOU NEED

BULLETIN 709 SIZE 3
across-the-line solenoid starter in Nema Type 1 enclosure.

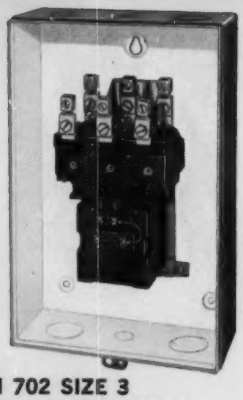
Where else could you possibly obtain—in one complete line—all of the desirable features of the ideal motor control...

1. **Smaller size**
2. **Greater reliability**
3. **Remarkable switching capacity**
4. **Longer life**
5. **Conscientious overload protection**
6. **Simpler installation**
7. **Complete accessibility**
8. **Beautiful appearance—either open or enclosed**
9. **Surprising light weight**

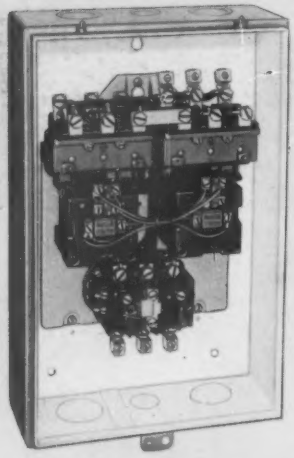
The heart of this new line of magnetic motor starters is the unique solenoid contactor. While it retains the famous A-B one-moving-part principle, it is completely new and far more efficient. This fact is reflected in reduced dimensions for all of these controls. Yet, this contactor design will perform reliably for many more *millions* of trouble free operations.

The new enclosures are very "eye appealing." When the open type starters are assembled into special panels, their neatness and compactness will delight the designers. Full details are in Publication 6100. Please write: Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.

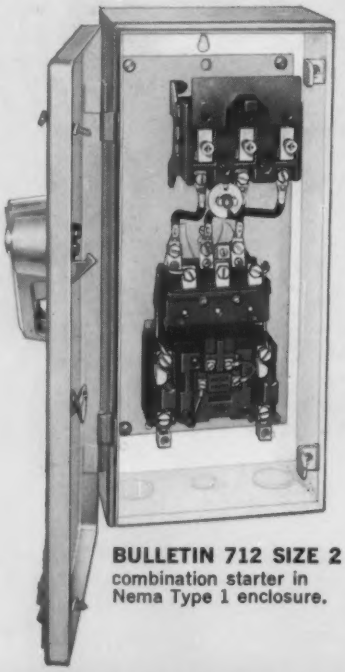
A-B QUALITY



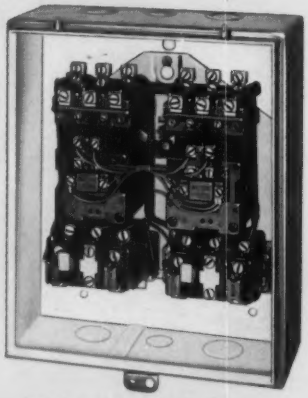
BULLETIN 702 SIZE 3
three-pole, a-c solenoid contactor in Nema Type 1 enclosure.



BULLETIN 705 SIZE 2
across-the-line reversing starter and overload relays in Nema Type 1 enclosure.



BULLETIN 712 SIZE 2
combination starter in Nema Type 1 enclosure.



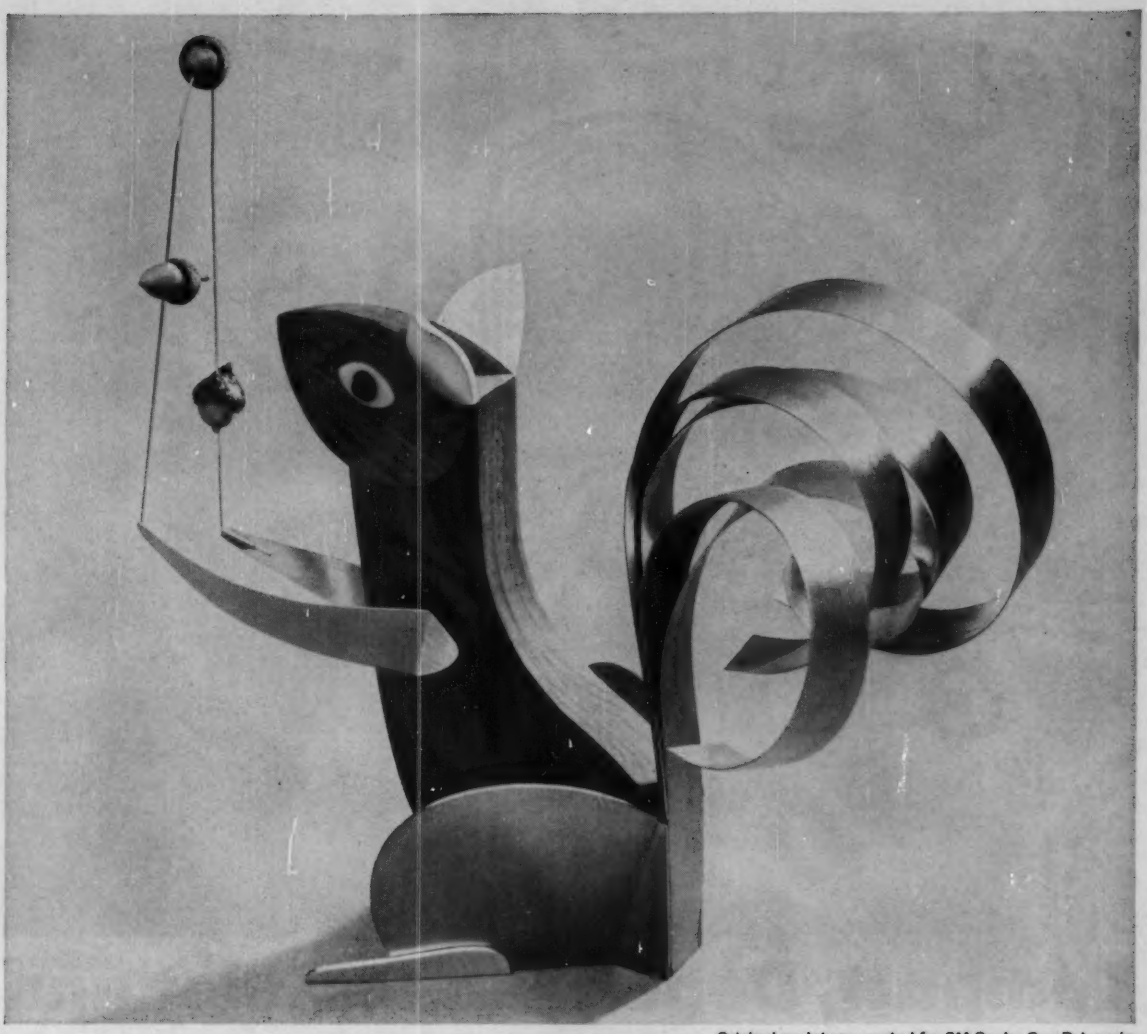
BULLETIN 715 SIZE 1
across-the-line, two-speed starter—with two overload relays per speed—in Nema Type 1 enclosure.

15-61-MR

ALLEN-BRADLEY

Member of NEMA

QUALITY MOTOR CONTROL



Original sculpture created for 3M Co. by Guy Palazzola

THRIFT

. . . Save three ways fabricating with 3M Adhesives!

When a switch from brazing to adhesive bonding saves a timer manufacturer $56.37 per thousand . . . when adhesives replace rivets and cut assembly costs 25% for a maker of metal containers . . . when a new structural adhesive cuts pump assembly rejections to nearly zero . . . can you afford *not* to look into the cost revolution being worked by modern 3M Adhesives?

Save time, money, materials! 3M Adhesives eliminate hole-making, countersinking, heat-treating. They bond without impairing integrity of structural members. No nuts, bolts, rivets, staples, welding, brazing. Metal thickness, joint size are reduced. One operation bonds *and* seals. Quality bonuses: bond strength exceeding materials bonded, smoother contours, improved fatigue resistance.

You can bond any material to itself or another, with 3M Adhesives. Item: tool manufacturer stopped costly machining of motor end plates from solid bronze, by adhering powdered iron discs to aluminum castings. Results: lower machining costs, increased strength and portability.

Why not? Let 3M Adhesives help *you* save on production! For a realistic analysis of the cost-cutting possibilities inherent in your operation, call your nearest 3M Field Engineer or write: AC&S Division, 3M Company, Dept. SBR-81, St. Paul 6, Minn.

"SCOTCH-WELD" is a Reg. T.M. of 3M Co. ©3M Co., 1961

What do you want to bond to what?
The 3M Squirrel is fabricated of these materials and bonded with 3M Adhesives, including "SCOTCH-WELD"® Brand Structural Adhesives:
1. Wood 2. Plastic 3. Aluminum 4. Stainless Steel 5. Copper 6. Brass 7. Glass

ADHESIVES, COATINGS AND SEALERS DIVISION

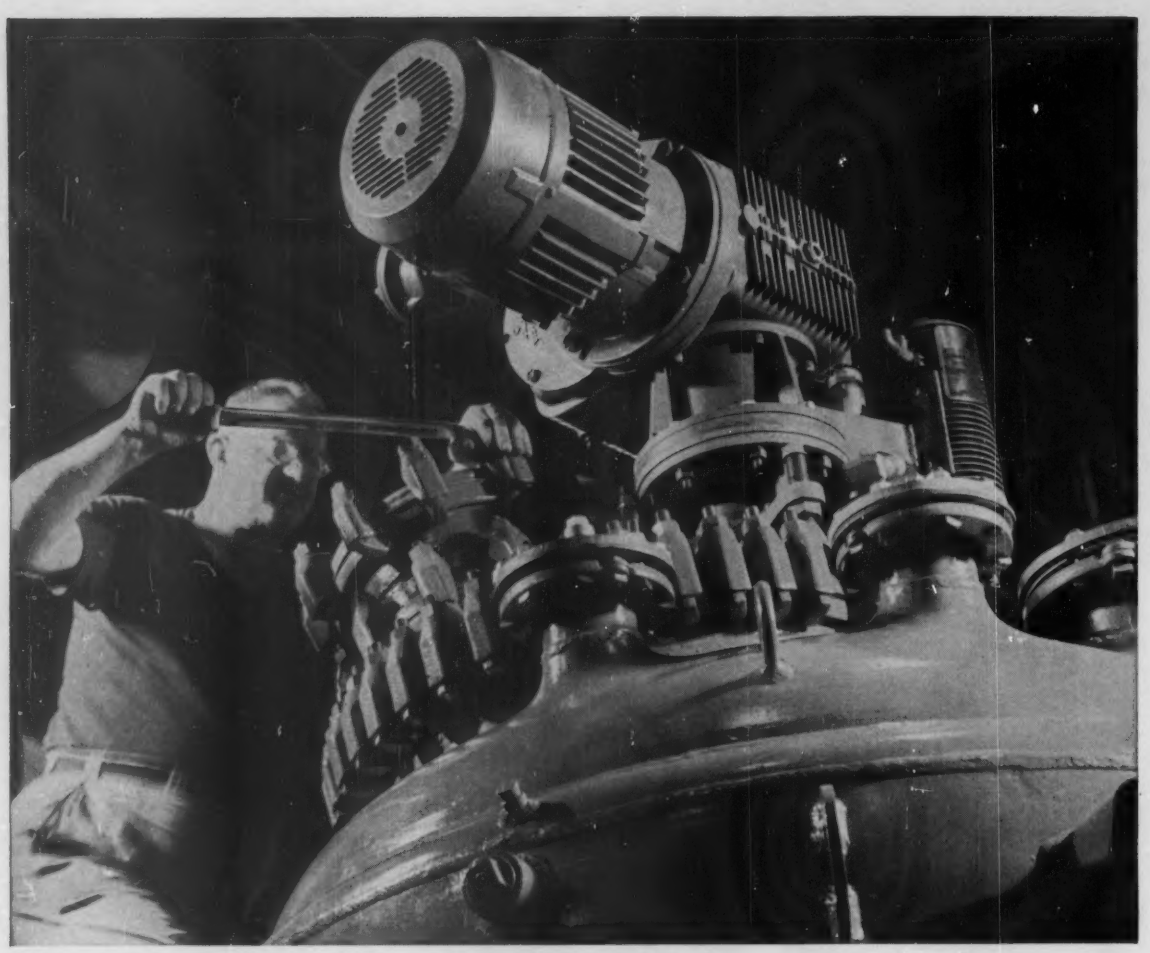
MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

←Circle 230 on Page 19

Circle 231 on Page 19



Compact, Dependable, Quiet and Powerful

that's what The Pfaudler Co. demands of gear reducers used for the agitator drives on their glassed-steel and alloy mixing vessels. That's why Pfaudler specifies Cone-Drive double-enveloping worm gear reducers for their line of TW Agitation Drives.

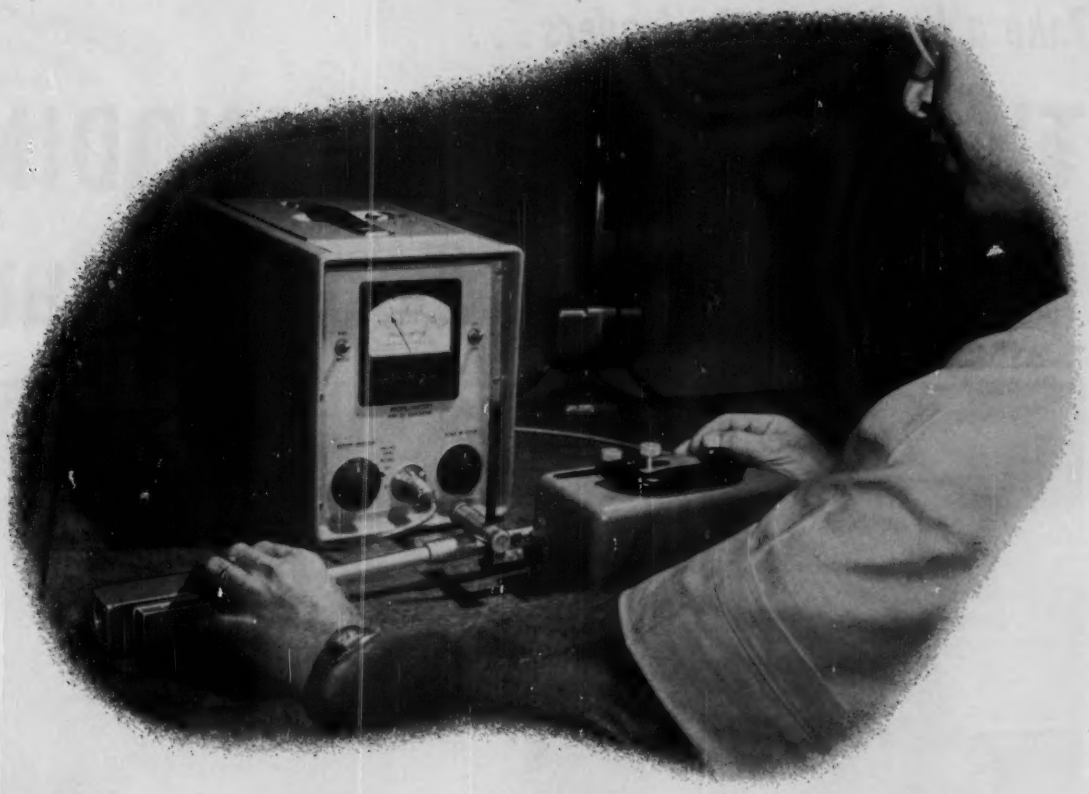
Cone-Drive gear reducers are available in capacities up to 60 HP and with 27 standard output speeds from 7.3 to 525 rpm (with 1750 rpm motor). Gear reducers can be hollow-shaft or solid shaft for left-hand, right-hand or vertical mounting.

Hollow-shaft gear reducer shown in the application above has a 5″ center distance and 30 HP maximum rating. Fan cooled models are available for increased thermal capacity. If maximum thermal HP capacity is required (equal to full mechanical HP ratings), water cooling coils may be installed.

CONE-DRIVE GEARS DIVISION MICHIGAN TOOL COMPANY

7171 E. McNichols Road • Detroit 12, Michigan • *Telephone* TWinbrook 1-3111

Circle 232 on Page 19



extra care for longer valve life!

The bores of all Valvair Speed King® valves are processed to a surface finish of 20 microinches or better... stems are held to 10 microinches.

To maintain its established standards of surface finish, Valvair precision-machines, then hones every main valve bore... grinds, hard-chrome plates, then polishes each stem. Prior to assembly, bores and stems are checked with a surface measuring instrument to be absolutely certain that surface finish meets Valvair's rigid requirements.

This painstaking attention to product quality is one of the reasons for Valvair's products' multi-million cycle dependability and is your guarantee of Valvair performance and service life. If you stake your reputation on the design, construction or operation of air controlled machinery, can you afford to use less than the best... the most dependable control valve components? Your nearby Bellows-Valvair Field Engineer can tell you more about Valvair quality and versatility. Call him today. Or, for more information, write Bellows-Valvair, Akron 9, Ohio, Dept. MD-961.

Bellows-Valvair

AKRON 9, OHIO

DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

8174

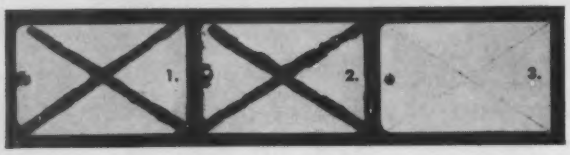
Circle 233 on Page 19

Take a lead from the leaders . . .

Three Amchem GRANODINE* Pre-Paint Economy and

All over the country frozen foods are showcased for shoppers in distinctively styled, colorful Weber display cases. Weber quality production—including Granodine pre-paint treatments for steel surfaces—assures store operators of refrigeration equipment that will stand up under hard wear for years to come.

GRANODINE—The obvious difference in pre-paint treatments



1. Solvent-cleaned—panels failed after 100 hours of accelerated testing.
2. Alkali-cleaned—panels failed after 100 hours of accelerated testing.
3. Granodine-treated—panels excellent after 336 hours of accelerated testing.

Phosphate Systems Provide Quality at Weber Showcase

One line alone achieves fuel savings of $9,000 per year; all three lines maintained by one operator for added labor savings!

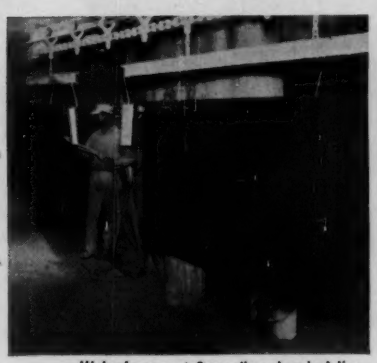
Versatile Weber Showcase & Fixture Company, Inc., headquartered in Los Angeles, places a high premium on quality of its diversified line—supermarket display cases, coolers and fixtures, prefabricated partitions, flooring and lab equipment to mention a few.

High on Weber's quality requirement list is pre-paint treatment of steel products. And their first choice in zinc phosphate coatings is Amchem Granodine*. Weber employs three separate Granodine phosphating lines to process hot- and cold-rolled steel.

Prime advantage of Granodine, according to Weber management, is "*Granodine gives us a better piece of merchandise as far as eye-appeal, wearability and service life are concerned.*" Additional savings continue to be recorded in time and labor (a single operator adequately controls all three lines), and a substantial $9,000 annual fuel savings (via use of a Granodine cold zinc phosphate).

Take a lead from the leaders. If you fabricate steel products—if you want uniform quality in paint adhesion and corrosion resistance—if you want personalized technical service that adds savings in time, labor and cash to your operation, you want to investigate Granodine by Amchem. A call to your local Amchem Representative will furnish you facts and figures.

*Granodine is Amchem's registered trademark for its conversion coating chemical used to produce phosphate coatings on steel.



Weber's newest Granodine chemical line handles steel shelving, large cooler boxes suspended from conveyor.

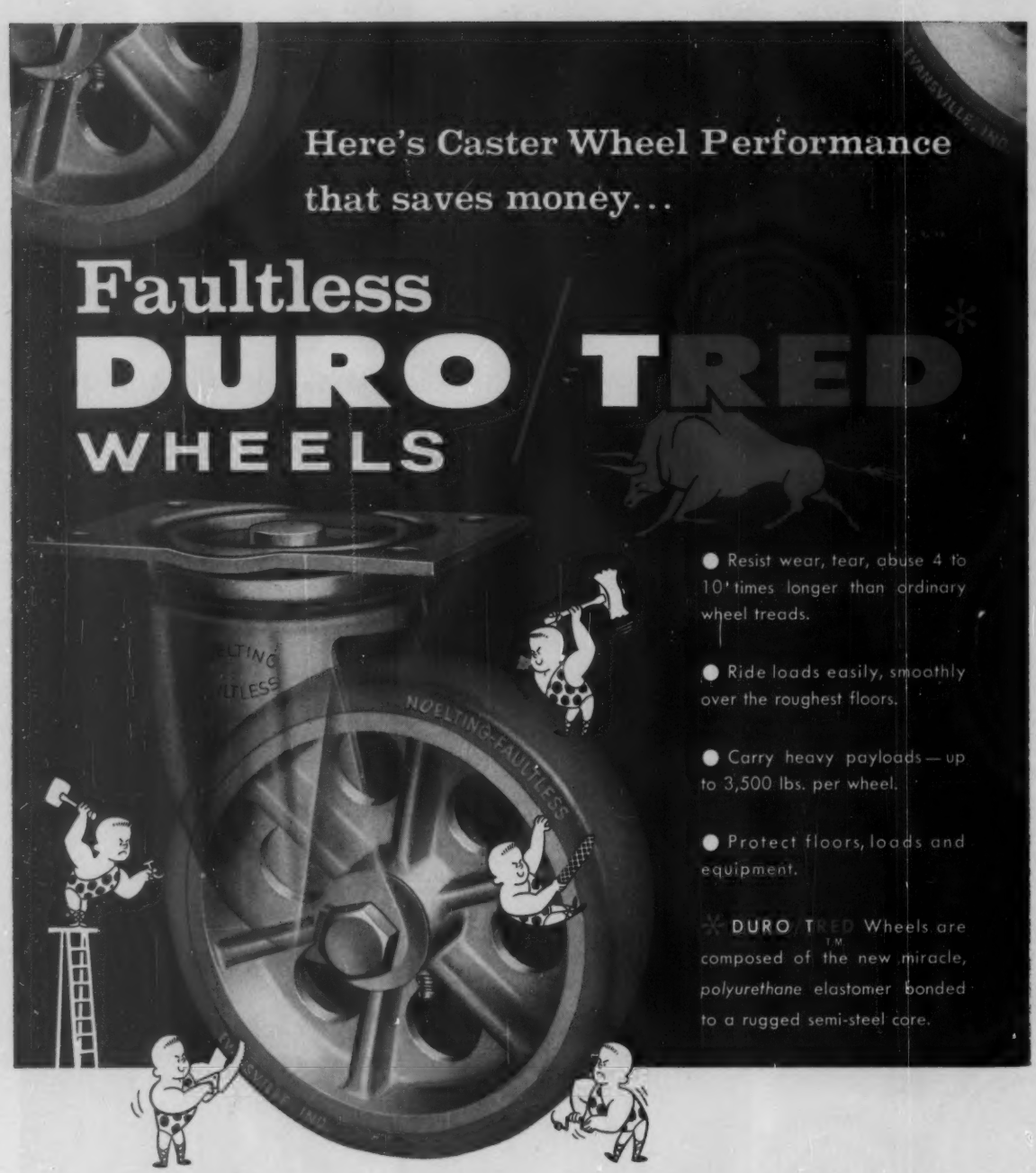
On Weber's third Granodine chemical line—a cold zinc phosphate—Weber Wall Sheet enters the washer.

Exiting at right from cold Granodine washer, Weber Wall Sheets receive prime coat spraying.

AMCHEM **GRANODINE**

Amchem is a registered trademark of **AMCHEM PRODUCTS, INC.** (Formerly American Chemical Paint Co.)
AMBLER, PA. • Niles, Calif. • Detroit, Mich. • St. Joseph, Mo. • Windsor, Ont.

Circle 234 on Page 19

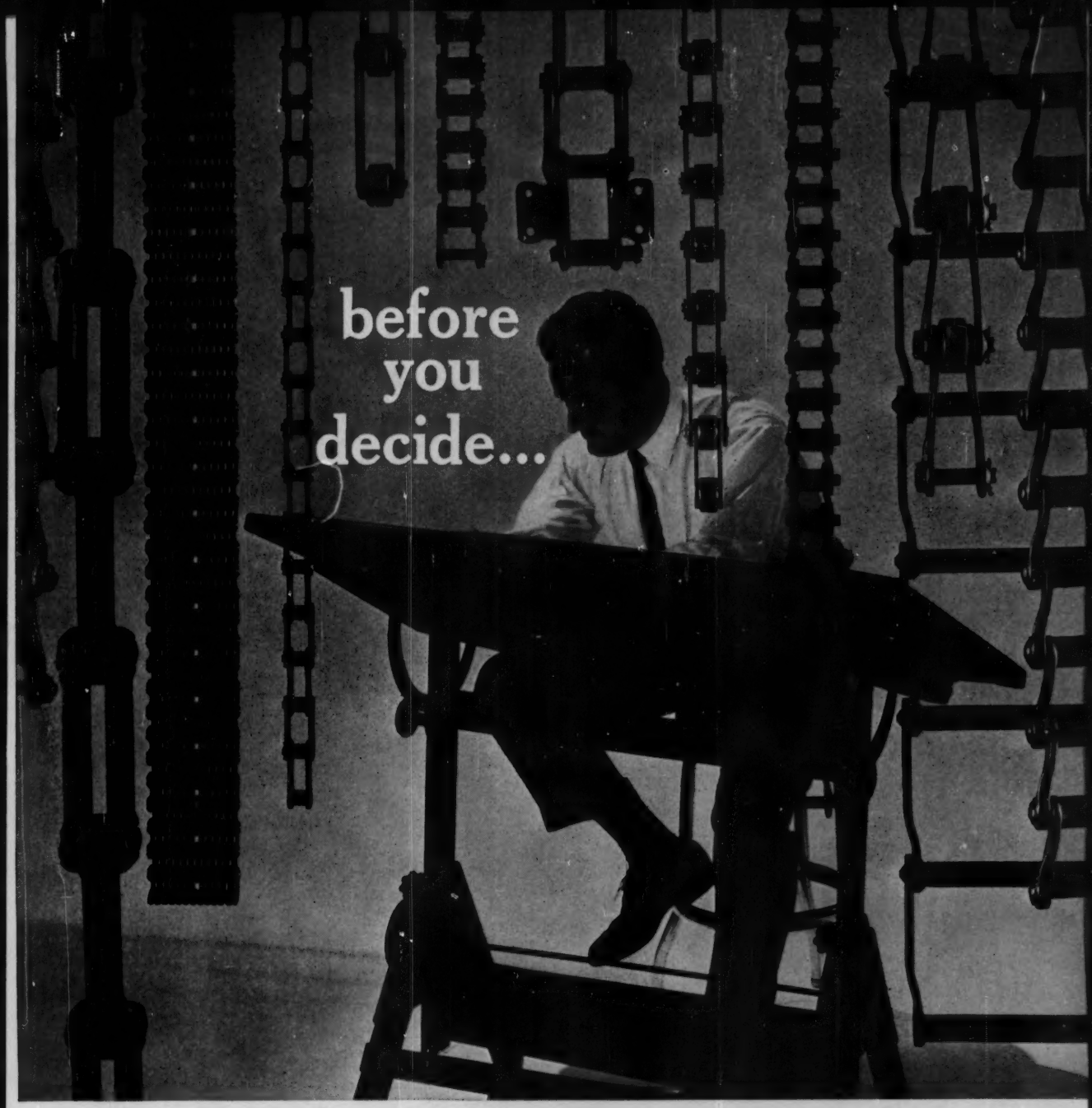

Here's Caster Wheel Performance
that saves money...
Faultless
DURO TRED
WHEELS
● Resist wear, tear, abuse 4 to 10 times longer than ordinary wheel treads.
● Ride loads easily, smoothly over the roughest floors.
● Carry heavy payloads — up to 3,500 lbs. per wheel.
● Protect floors, loads and equipment.
* DURO TRED T.M. Wheels are composed of the new miracle, polyurethane elastomer bonded to a rugged semi-steel core.
NOELTING-FAULTLESS

With Duro/Tred Wheels, your caster maintenance costs can be chopped considerably. Special properties of *polyurethane*—strength, resilience, wearing quality—mean Faultless Duro/Tred Wheels cut costly downtime of castered equipment in your plant. New Faultless Duro/Tred Wheels are manufactured in 5", 6", 8", 10" and 12" diameter wheel sizes to fit most larger Faultless swivel and rigid industrial casters. *Free,* fact-filled literature sheet detailing specifications and sizes of Duro/Tred Wheels is available from Faultless or your local Faultless Industrial Distributor, who stocks a wide range of casters at his warehouse for immediate shipment.

Faultless Caster Corporation
EVANSVILLE 7, INDIANA

Branch Offices in principal cities; see the Yellow Pages of the telephone book under "Casters." Canada: Stratford, Ontario.

NOELTING Faultless Casters



consult a chain specialist... consult Link-Belt

IT'S THE FAST, EASY WAY TO CHOOSE CHAIN. Offering you hundreds of standard chains, Link-Belt can help you choose the one chain that's precisely right for your power transmisson or conveying application. Each chain is as individual as a thumbprint, with characteristics mated to specific job needs. And Link-Belt experience is at your service—to help you evaluate particular performance factors . . . to save you time in choosing the one best chain for your application (in terms of high efficiency, low total cost). Contact your nearest Link-Belt office. Ask, too, for catalog 1050 covering the complete line of Link-Belt products and components for materials handling and power transmission.

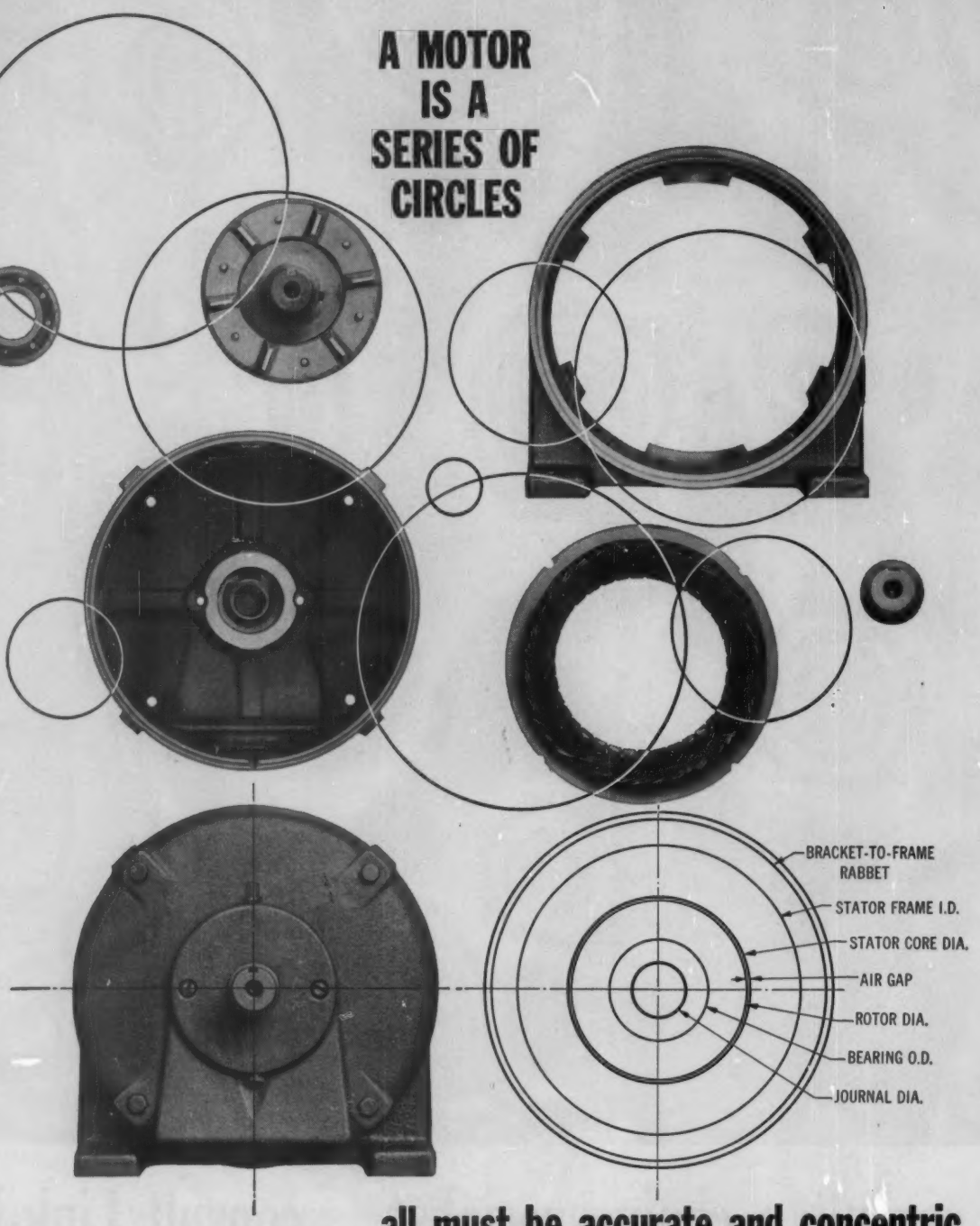
LINK-BELT

CHAINS AND SPROCKETS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1, To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs; Switzerland, Geneva. Representatives Throughout the World. 15.718

Circle 236 on Page 19

A MOTOR IS A SERIES OF CIRCLES



all must be accurate and concentric

In manufacturing Elliott Crocker-Wheeler motors, a dozen critical "circles" are formed accurately and concentrically through unique and extraordinarily precise production methods. The result is exact alignment of all parts, true and uniform air gap, free-spinning rotor, quiet, cool, dependable operation.

■ *Elliott Crocker-Wheeler integral-hp a-c and d-c motors—from smallest to largest—are offered in all conventional enclosures and modifications; with insulation to suit the application, including* EPOSEAL *epoxy insulation for use where conditions are most severe.*

W1-3

ELLIOTT COMPANY

GENERAL OFFICES: JEANNETTE, PENNSYLVANIA

PLANTS AT: Jeannette and Ridgway, Pa.; Springfield, Ohio

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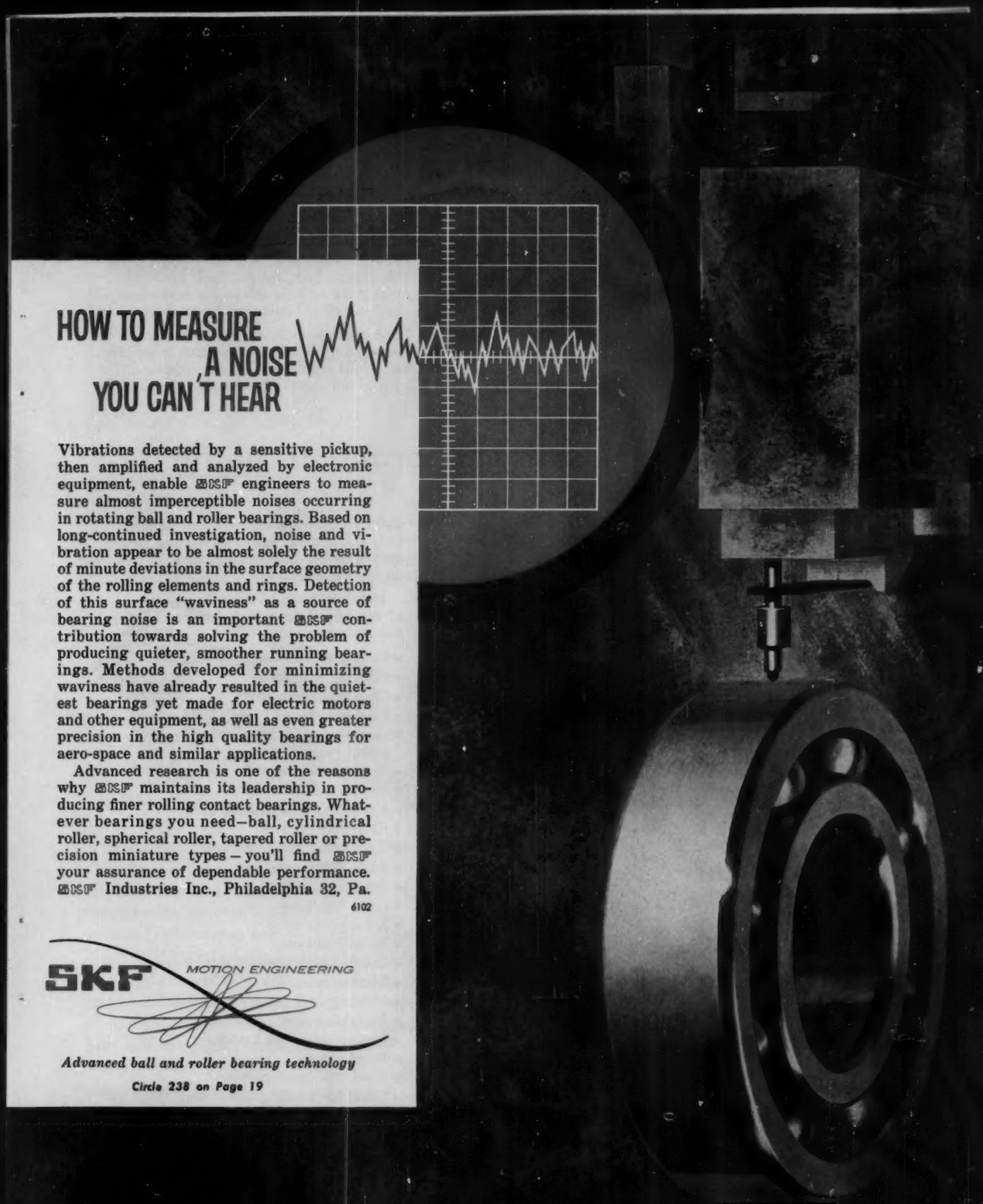


HOW TO MEASURE A NOISE YOU CAN'T HEAR

Vibrations detected by a sensitive pickup, then amplified and analyzed by electronic equipment, enable SKF engineers to measure almost imperceptible noises occurring in rotating ball and roller bearings. Based on long-continued investigation, noise and vibration appear to be almost solely the result of minute deviations in the surface geometry of the rolling elements and rings. Detection of this surface "waviness" as a source of bearing noise is an important SKF contribution towards solving the problem of producing quieter, smoother running bearings. Methods developed for minimizing waviness have already resulted in the quietest bearings yet made for electric motors and other equipment, as well as even greater precision in the high quality bearings for aero-space and similar applications.

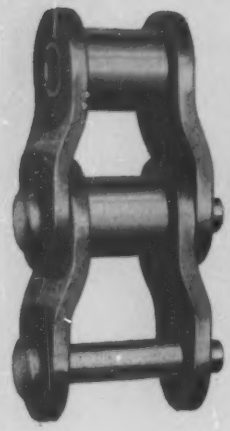
Advanced research is one of the reasons why SKF maintains its leadership in producing finer rolling contact bearings. Whatever bearings you need—ball, cylindrical roller, spherical roller, tapered roller or precision miniature types – you'll find SKF your assurance of dependable performance. SKF Industries Inc., Philadelphia 32, Pa.

6102

SKF MOTION ENGINEERING

Advanced ball and roller bearing technology

Circle 238 on Page 19

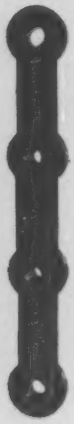


Steel Thimble Roller Chain—If you are driving a mixing drum or other equipment at an inclined angle, you can cut wear on chain drive by using this Jeffrey "offset" STR type.

Don't let work-horse appearance fool you . . . chain is a *precision* product. Its tensile strength, fatigue limit and resistance to wear affect the performance and life of *the equipment you make.*

Jeffrey chain is engineered to provide maximum strength with minimum weight, but with ample reserve strength to withstand sudden and heavy overloads.

Jeffrey chain makes good products better!



STR Hollow Pin Chain conveys bread through bakery ovens on smooth-running rollers. Conveniently spaced hollow pins provide an easy method for attaching trays or other fixtures.

Steel Knuckle Chain—Movable packer plate inside this cylindrical refuse truck is operated by using Jeffrey chain as a tension element and driving chain from the truck power takeoff.

Jeffrey engineers will help you design for most efficient use of power and longer lasting power transmission and conveying assemblies.

Here are some of the many types of equipment for which Jeffrey chain has been specified:

- Bakery equipment
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- Coal washers and jigs
- Conveying, loading, unloading and piling machinery
- Concrete mixers and pavers
- Cranes and shovels
- Earth and rock drilling units
- Elevating graders
- Excavators and trenchers
- Farm machinery
- Food machinery
- Glass batching
- Ice making units
- Industrial ovens
- Lumber and sawmill machinery
- Mining machines
- Pickling and plating machines
- Portable gravel plants
- Refuse collection trucks
- Road rollers
- Steel mill machinery
- Units for washing and drying materials

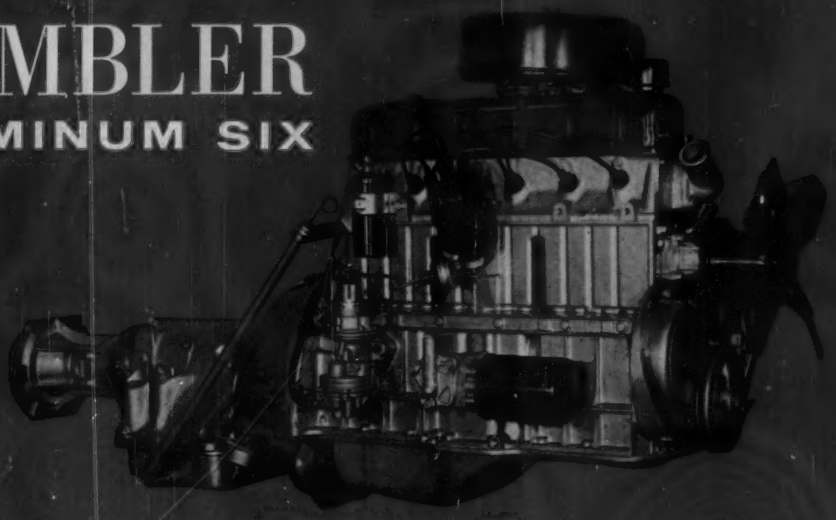
The Jeffrey Manufacturing Company, 798 North Fourth St., Columbus 16, Ohio.

If it's conveyed, processed or mined, it's a job for Jeffrey.

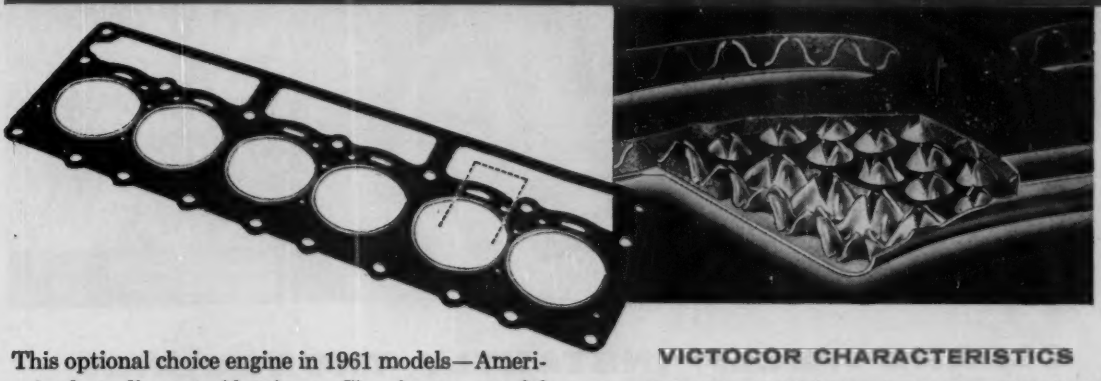
JEFFREY

Circle 239 on Page 19

RAMBLER
ALUMINUM SIX



sealed with Victocor®



This optional choice engine in 1961 models—America's first die-cast Aluminum Six—is a powerful friend-maker for Rambler. It saves 80 pounds weight—resulting in easier car handling with excellent performance and satisfying economy.

A VICTOCOR cylinder-head gasket seals this fine engine. VICTOCOR's superior compressible and resilient sealing properties are combined with a stainless steel bottom layer that provides maximum heat and corrosion resistance.

VICTOCOR's exclusive metal core-Asbestopac* construction dissipates heat build-up . . . reduces torque loss . . . and maintains dimensional stability. The Asbestopac component retains all coolants.

Synthetic rubber-asbestos sheet packing

VICTOCOR CHARACTERISTICS

Low Torque Loss • High Heat Resistance • High Corrosion Resistance • High Crush Resistance • High Dimensional Stability • Various Gauges Available—as thin as .030-.035

Cross section above shows how thin steel core is die-formed with continuous projections (800 per sq. in.) alternating in each face. Victocor sealing element layers, top and bottom, are bonded simultaneously, mechanically and chemically, into integral structure with core. Deep penetration of core projections increases stability and heat conductivity. The stainless steel bottom of gasket is formed into the combustion chamber openings.

WRITE FOR CATALOG NO. 505A

Available in standard type and modified structures, VICTOCOR gaskets have wide adaptability for automotive and industrial machinery sealing. Consult your Victor Field Engineer, or write on your business letterhead for catalog on VICTOCOR and other superior packings. Victor Mfg. & Gasket Co., P.O. Box 1333, Chicago 90, Illinois. Canadian Plant: St. Thomas, Ontario.

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Sealing Products *Exclusively*

GASKETS • PACKINGS • OIL SEALS • MECHANICAL SEALS

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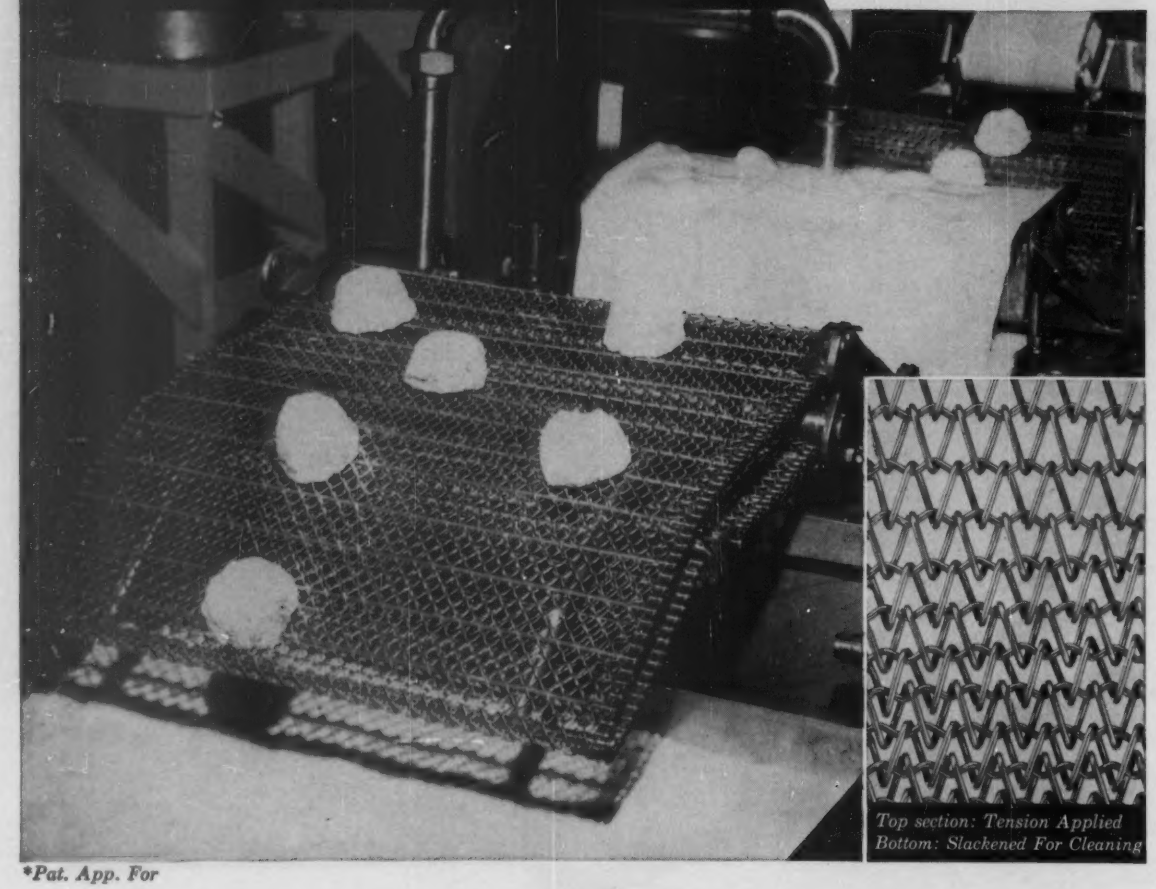
Cambridge Collapsible Metal-Mesh Belt*



Top section: Tension Applied
Bottom: Slackened For Cleaning

**Pat. App. For*

CLEANS ITSELF—INSTANTLY, THOROUGHLY

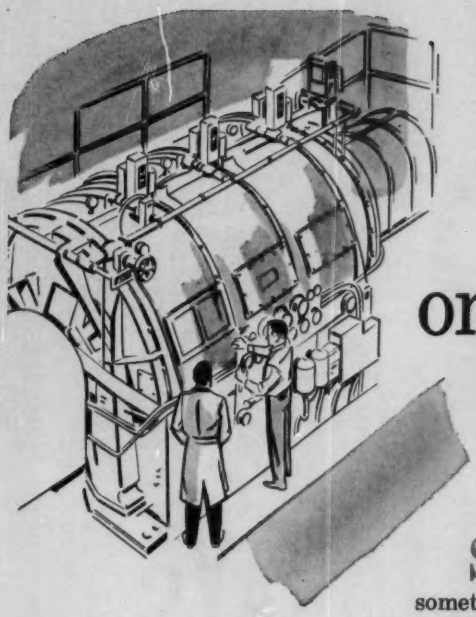
Just slacken tension on the Cambridge Collapsible Belt, run it through a cleaning tank, and watch it clean itself. Because each cross rod separates completely from the spirals, bacteria and odor-producing dirt, oils and greases flush away instantly and thoroughly. Yet, the Cambridge Collapsible Belt gives you all the metal-mesh belt advantages you need for fast, thorough processing.

There is a complete line of Cambridge Belts in special and standard metals and alloys to meet your specific requirements—custom built in any one of nine basic weaves to insure the most efficient processing.

Experienced Cambridge Field Engineers—experts in their field—are available to discuss your needs and help you select the belt best suited to your operations. Or, they can offer you sound advice on the installation, operation and maintenance of your Cambridge Belts. Talk to your Cambridge man soon. He's listed in the Yellow Pages under "Belting, Mechanical". Or, write for free 130-page reference manual.

The Cambridge Wire Cloth Co.
Department N • Cambridge 82, Maryland

Manufacturers of Metal-Mesh Conveyor Belts, Flat Wire Conveyor Belts, Wire Cloth, Wire Cloth Fabrications, Gripper ® Metal-Mesh Slings



There's more than one kind of Dynamatic service!

Some folks think of "service" as the help you need when something goes wrong. That's important, of course, and Dynamatic supplies it with competent service representatives located in principal cities throughout the United States and Canada. In addition, around-the-clock seven-days-a-week service is available from the factory.

But there's another kind of service that's equally important—the service that starts even before you have purchased Dynamatic speed control equipment. It's being able to sit down with your Dynamatic representative, knowing that he has very likely been up against a problem about the same as yours before; that he has a background gained through years of experience in this specialized field.

Dynamatic service begins with your first inquiry, includes start-up supervision by factory service engineers, and follows through for the life of the equipment.

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Robbins & Myers Series-Wound (Universal) and Induction Motor Parts can increase your products' life expectancy, whether you make portable tools for farm, home or industry; household appliances; business machines; or other power-driven items.

R&M engineers will select—or help *you* select—exactly the right size, shape and weight motor parts to fit your limitations. Parts are precision-built, using modern manufacturing techniques—an outstanding example is R&M's machine-wound armatures (details at right). Quality materials assure dependable, long-life performance under severe operating conditions and high speeds. And, R&M's high-volume production means low unit cost, to help keep the price of your products competitive.

Standard R&M Motor Parts are available in a large variety of mechanical details and electrical characteristics. Should performance requirements be unique, R&M also offers custom-designed parts. Write today for Bulletin 445A-MD.

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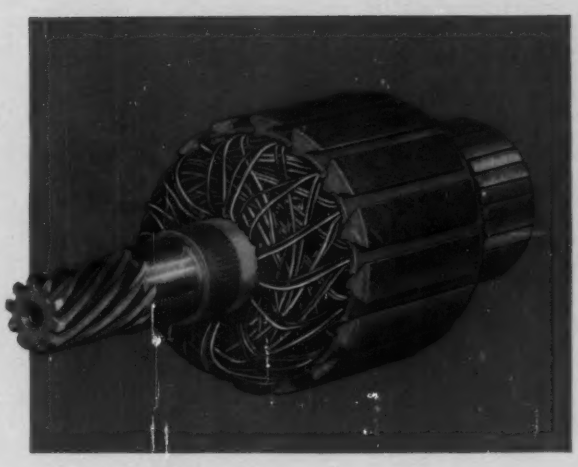
Circle 243 on Page 19

FHP MOTOR PARTS

ROBBINS & MYERS PRECISION MACHINE WOUND ARMATURES

New R&M armature winding techniques provide longer, more dependable service. Coils are wound simultaneously and are exactly identical, assuring identical electrical and physical characteristics. Coils are uniformly positioned and anchored securely. Interlocked winding pattern resists conductor and coil end movement . . . minimizes abrasion of wire insulation, a common cause of high speed armature failure. Maximum coil end exposure permits greater heat dissipation, prolonging armature life. Uniform electrical characteristics reduce arcing at brushes, improving commutation and lengthening brush life.



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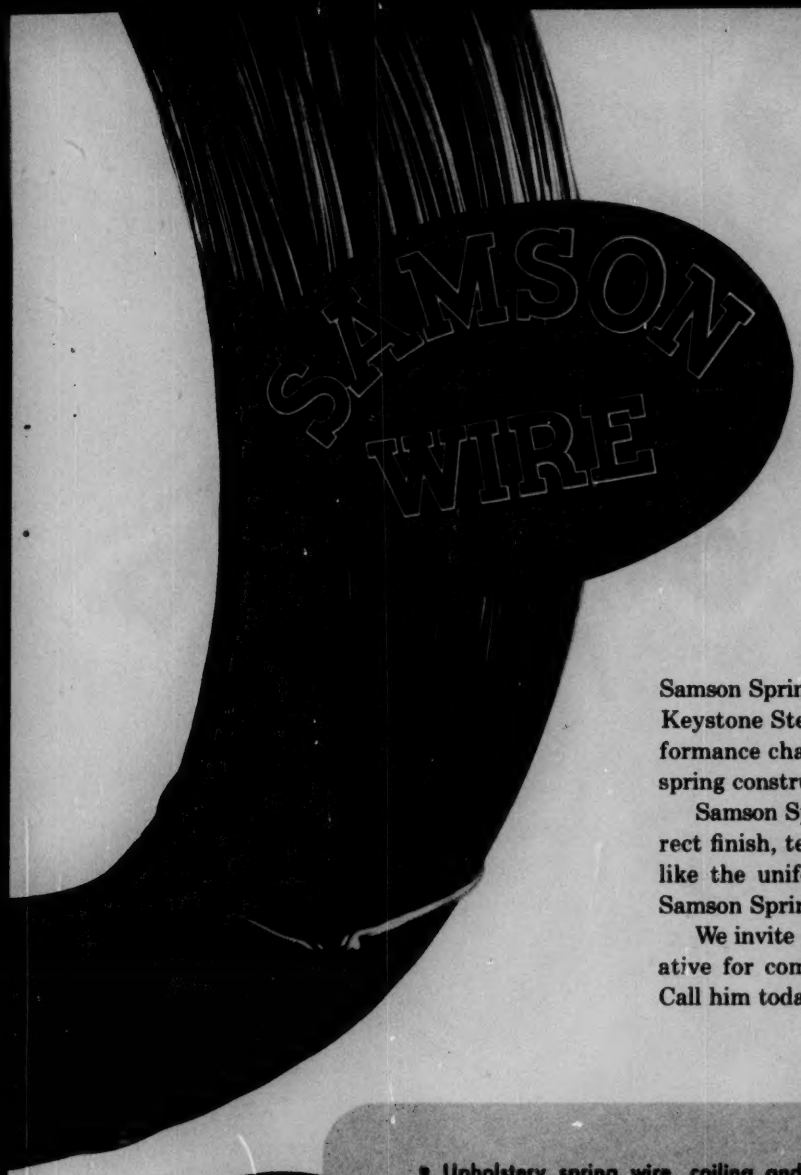

. . . meets every spring construction requirement

Samson Spring Wire—an up-to-the-minute product of Keystone Steel & Wire Company, with modern performance characteristics—is available to fulfill every spring construction.

Samson Spring Wire is custom made with the correct finish, temper and tensile to fit each use. Users like the uniform size and coiling characteristics of Samson Spring Wire.

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name your need . . .

- Upholstery spring wire, coiling and knotting quality
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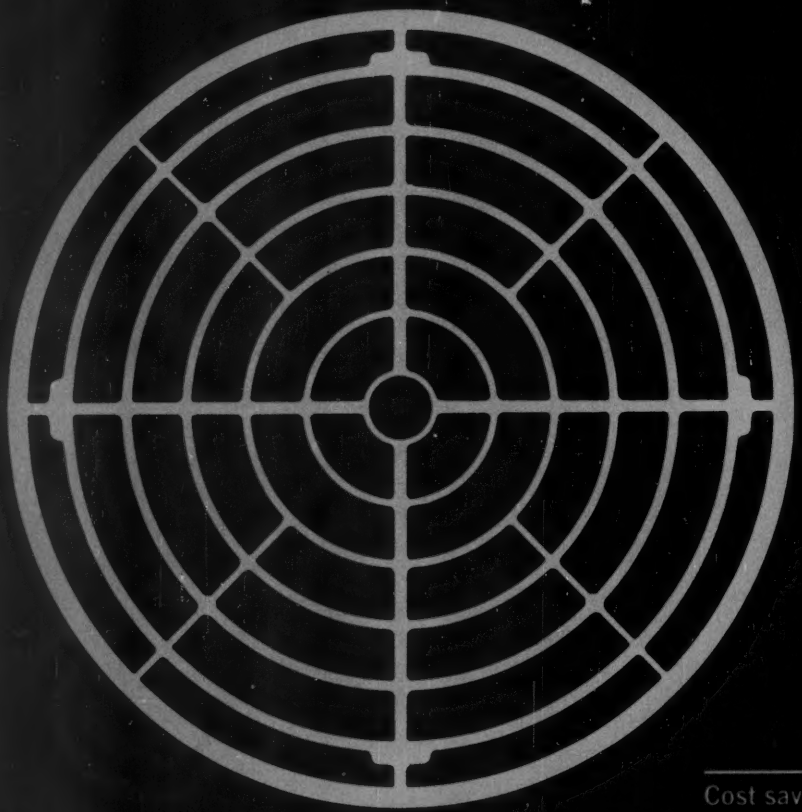
KEYSTONE
WIRE FOR INDUSTRY



Cost saving: 33%

are you getting your metal's worth?"

The intake tubes of the Waterous Company's model CMB fire pump suck in 1250 gallons of water a minute. Rocks and other foreign matter can get sucked in too—which would have disastrous effects on the pump. A screen is needed on the intake tubes, a screen that's tough and corrosion resistant, with extra thin vanes and a smooth surface for unimpeded water flow.

Originally these screens were fabricated from sheet brass, with the vanes brazed together. An expensive material and method for a simple but important component.

Today these screens are die cast of Zamak at a cost saving of 33% by Twin City Die Casting of Minneapolis. The tapered vanes have a minimum wall thickness of 1/32" or less. Zamak is the only die casting material that can fill these thin sections and still provide the strength, corrosion resistance and smooth "as cast" surface necessary.

To find out how you can put zinc die casting to work cutting your production costs, write today to The New Jersey Zinc Company for your set of Zamak engineering data books detailing the properties, use design techniques and machining practices of the Zamak alloys. Remember—Zamak gives you more for less. Are you getting your metal's worth?

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HORSE HEAD PRODUCTS

DESIGN
August 31, 1961

The Recruiters

JOE had been pestering his boss to be allowed to attend the engineering convention. How could an Engineer keep up with his Profession and Broaden his Horizons if he didn't Participate in Society Activities?

So the boss relented, and Joe spent a stimulating three days in the big city—but not exactly what he, or his boss, had anticipated.

Joe broadened his horizons, all right. The high-pressure recruiting boys saw to that. The upshot was that Joe's head was turned; he now saw his old boss and his company as a bunch of fuddy-duddies. And he accepted one of the glittering offers of a glamorous new job with a brilliant future.

Although Joe is already disillusioned with the new job, it will be many a long day before his former boss will permit one of his valued engineers to be exposed to such hazards again.

How many other management people, thus burnt, tend to hold back their engineers from attending meetings and shows? There is evidence that engineering meeting attendance is suffering because of this situation.

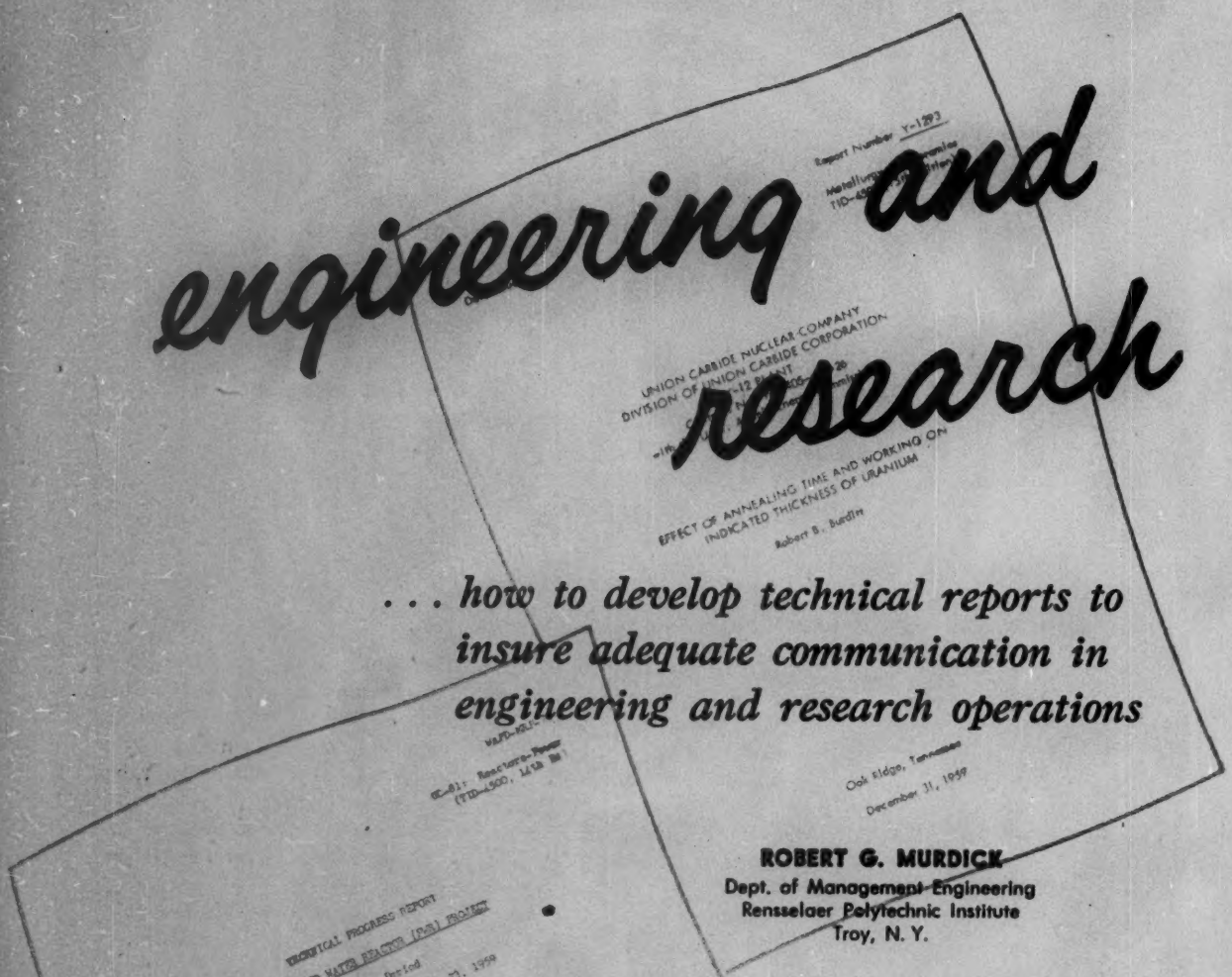
Yet the opportunity to become acquainted with another engineer at a meeting has often led to a fruitful new association. An engineering supervisor, attending and participating in a meeting as an engineer, has an excellent chance to observe up-and-coming engineers in a professional—and somewhat relaxed—atmosphere.

Job changes resulting from this sort of contact are a normal hazard —or benefit—of engineering meeting attendance. There is nothing unprofessional about such exchanges.

Engineers might well resent recruiting's interference with the normal workings of professional meetings. Is it too much to hope that, as a result of such resentment, they will concentrate on the real purpose of the meeting and the fellowship of other engineers, leaving the recruiters to entertain—and maybe hire—each other?

Colin Carmichael
EDITOR

engineering and research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DIVISION OF UNION CARBIDE CORPORATION
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Robert B. Murdick
Oak Ridge, Tennessee
December 31, 1959
TECHNICAL PROGRESS REPORT
For the Period
February 24, 1959 to April 23, 1959
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. . . how to develop technical reports to insure adequate communication in engineering and research operations

ROBERT G. MURDICK
Dept. of Management Engineering
Rensselaer Polytechnic Institute
Troy, N. Y.

THE engineering and research job is not complete until it is properly documented. Unfortunately, many engineers and researchers fail to recognize the most important purpose of a report—to disseminate scientific knowledge so that others do not have to duplicate research already done. Beyond this basic reason for reporting progress, achievement, and failure, there are, of course, other important business reasons. These include customer requirements, internal communication, and legal and patent considerations.

There are a number of different types of engineering and research reports and it is important that the primary purpose and nature of each be thoroughly understood. The most important kinds of reports are:

1. Internal memo, or topical report.
2. Terminal technical engineering and research report.
3. Project progress report.
4. Technology or functional progress report.

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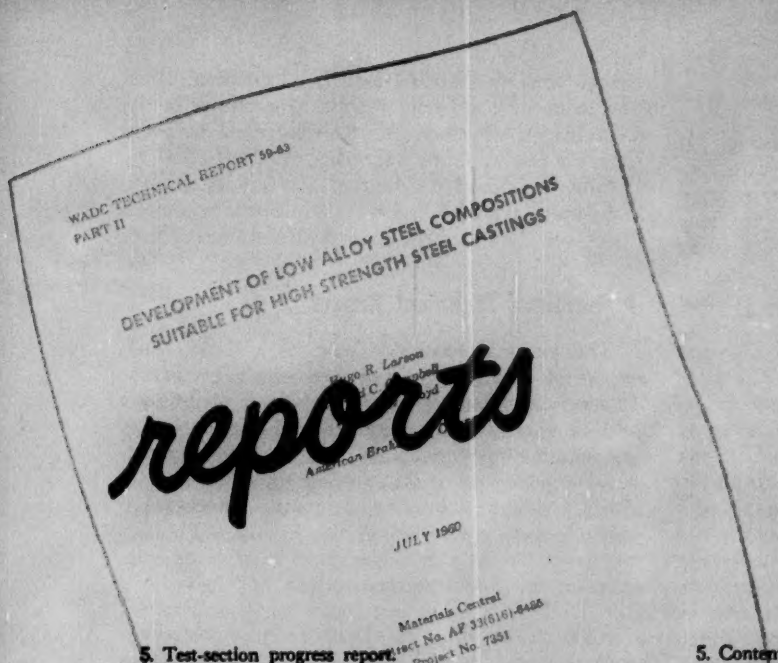


5. Test-section progress report.
6. Summary periodic business report.
7. Terminal project report.

Internal Memo

The purpose of the internal memo is primarily to facilitate timely internal communication. It usually covers preliminary or tentative results which are needed by other technical groups. It is sometimes called a topical report, because it may include results of a special study which are urgently needed. On the other hand, it may be used to report some interesting but incidental result.

Style: The style of the internal memo should not be restricted. Rather, the writer should be allowed freedom of expression, the use of idiom, and the opportunity to express his opinions. However, the writer should not forget that the primary purpose of the report is to communicate, not to confuse or to entertain.

While there should be freedom in style, there should also be some restrictions in format. The number of scientific reports has been growing at an exponential rate until the annual rate is around 100,000. In one year, over 60,000,000 pages, or the equivalent of 465 man-years of round-the-clock reading, is being turned out by laboratories and research centers throughout the world. It is difficult even to keep up with abstract publications in some technical fields. All this argues for a standardized format, so that readers can quickly determine the subject matter of the report, and whether or not it contains information of use to them. A topical report might typically have:

1. A cover, with the following information: An identification or serial number, a specific title, the author's name, the company name, and the date.
2. A title page with a 3 x 5-in. box, Fig. 1.
3. Routing page, showing distribution of the report.
4. Table of contents and, if necessary, a list of illustrations.
5. Contents, arranged to begin with the purpose of the report, and conclusions. For example:

Digest Purpose of test.
Principal test conditions.
Conclusions (including significance of conclusions).

Body Test facility.
Test procedure.
Test results.
Analysis (including analysis of data and discussion of results).
Appendix (data and detailed analytical work).
Bibliography.

For an analytical report, the format might be standardized as follows:

Digest Purpose of investigation.
Principal assumptions.
Conclusions (including significance of conclusions).

Body Analysis (including all assumptions, analytical work, and discussion of results).
Appendix (data used, and detailed derivations needed for main analysis).
Bibliography.

Timing: The timing of the internal memo is im-

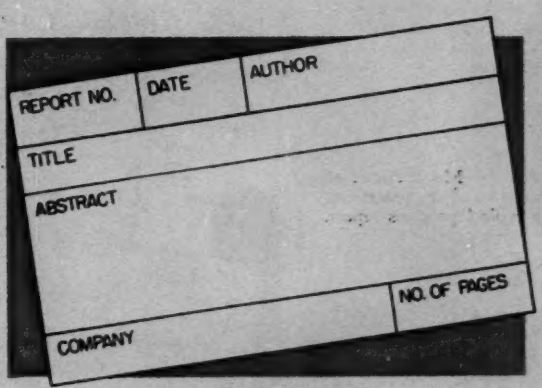


Fig. 1—Information "box" for title page of internal memo.

portant. Every small advance or interesting but irrelevant discovery should not be issued with fanfare. Deciding factors are: 1. Is the information needed by the design group immediately to help them maintain their schedule? 2. Has work along this line of investigation been carried as far as it will be? 3. Has a major milestone been reached in a long investigation?

There are three obstacles which frequently stand in the way of timely report writing: 1. The press of new work often prevents the engineer or researcher from working on the report. It is up to the group manager to see that the report is not held up for this reason. 2. Many scientists dislike writing. Again, it is up to the manager to educate his men on the necessity for reporting results, and to show them how they will benefit from the development of their skill in report writing. 3. The typing and reproduction group may be too small to handle the volume of reports. Engineers and scientists prepare their reports on time, then see them held up for weeks or months, until their value is completely lost. Engineers then write fewer reports and depend upon casual personal contact as a means of interchanging technical information. Obviously this is a poor method of disseminating vital information.

Reproduction: Because of its nature, a topical report is usually prepared by a very inexpensive method such as hectograph or, for very short reports, diazo. Sometimes, when distribution is large, offset is used. Illustrations may be free-hand sketches, photographs, or engineering drawings.

Distribution: Reports should be routed only to people who have a need for the information. Often the tendency is to send reports to everyone in the organization directory. If this were done in every case, the cost would be staggering.

Often, standard distribution lists are established for certain types of reports. While this is often a timesaver, the lists must be revised from time to time.

Terminal Technical Report

The terminal technical report is a formal final report of an investigation or project. Whereas the internal memo or topical report covers preliminary results, the terminal report is the culmination of a scientific investigation or test. It may be circulated outside the organization to the customer, to other divisions within the company, and occasionally to other companies in the industry. The latter is particularly true for reports of work prepared under government contracts.

Style: A terminal report is, of course, more formal than an internal report. This does not mean that the writer should try to impress others with complicated jargon. Although he is writing for people skilled in the art, the report writer should try to express himself in clear, straightforward language. Most report readers are either lazy or busy. If a report is not readable, they may feel it is not worth their time to decipher it.

Format: The form of the terminal report may be standardized in the same way as the internal memo. Quality of reproduction should be much higher, however, because such a report represents the organization or the company to outsiders. It should be looked upon to some extent as a supplementary selling medium.

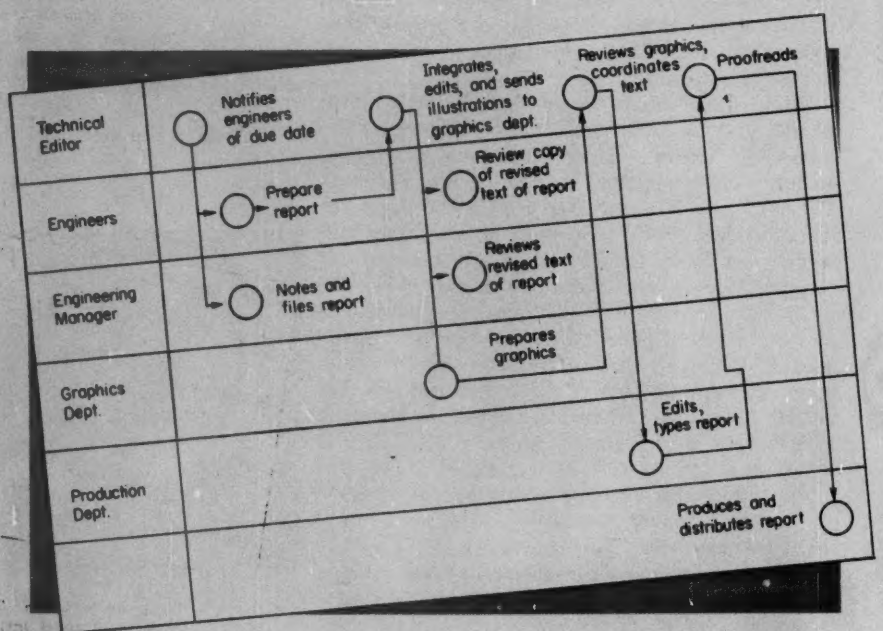


Fig. 2—Flow-chart of steps used in processing a typical progress report.

Reproduction: Typing may be proportional-spaced and justified, where costs are not excessive. Xerox and Varityping permit the use of typeset headings, or their equivalent, at reasonable cost. The report should be printed by a process at least as good as offset. Drawings should be prepared by draftsmen or technical illustrators. Photographs may be reduced to photo-offset masters, and should be at least 120 screen.

Project Progress Report

The progress report has attained widespread use with the rise of defense and government contracts. At one time, the progress report was a method of letting the customer know, at irregular intervals, how things were coming along. Now, the progress report must come from the engineering and research group with the regularity of an assembly line.

Timing: The progress report, when used on large projects, may be issued quarterly or bimonthly. It is not uncommon, however, to find that the customer requires a monthly report. On smaller projects, reports may be required more frequently.

Form: The format, content, and style are woven together in the concept of the progress report, Fig. 2 and 3. The format may be based upon dividing the entire project into tasks, subtasks, and jobs, or it may be based upon divisions parallel to engineering echelons and groups in the engineering organization. Often these are almost identical.

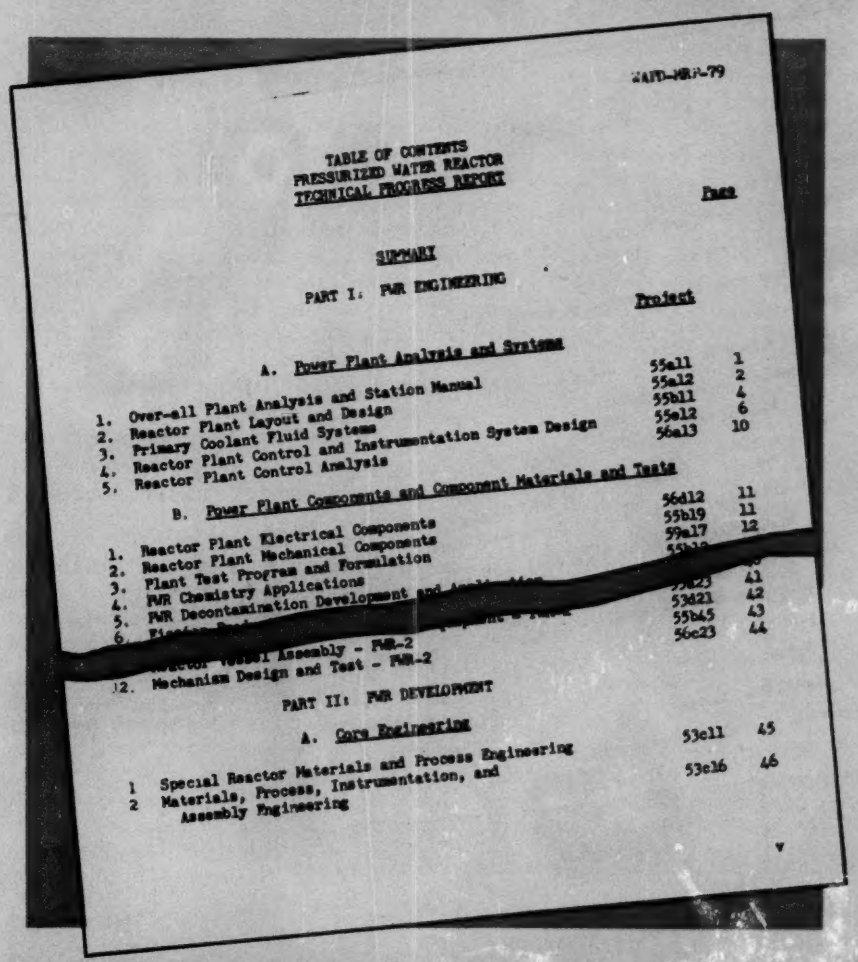
The report, complete with headings and subheadings, is usually first prepared by a technical editor or co-ordinator working with engineering management. From time to time, minor revisions are required as investigations are completed and new ones started. There may be many levels of subheadings if the customer wants to put his finger on a small segment of the work.

Both content and style of the progress report are designed to provide the following information:

1. Progress made since the last report. If none, why.
2. Problems encountered, and what is being done about them. If nothing has been done, what and when something will be done.
3. Results of tests or analysis, in condensed form.
4. Significance of these results to technical progress and to the schedule.
5. Adherence to schedule. If schedule is not being met, why not, and what is being done to bring work back on schedule.
6. Budgeted costs and costs-to-date, if necessary.

Length: Progress reports may be as long as 200 pages. In such cases, engineering management usually writes a one or two-page summary at the beginning of each major section.

The progress report should be thoroughly edited, then carefully reviewed by someone who is in tune with top-management policy and thinking. This



WAPD-MRP-79

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Fig. 3—Part of table of contents for typical project progress report.

will ensure that the progress reports will present a continuity of company policy.

Reproduction: Offset printing on good bond paper, heavy-paper covers, and good-quality illustrations should characterize the progress report. Illustrations should be accumulated while the report is being written, since more processing time is required for these than for the text. Within 10 to 15 days after individual reports have been received from the engineers, the entire report should have been organized, edited, typed, proofread, and reproduced.

Technology Progress Report

Often, engineering and research organizations have a supporting group of scientists carrying on continuing long-range investigations, whose interim results are used by the engineering organization. Such research is not directed toward the accomplishment of short-range goals on a specific schedule.

Progress in technology is likely to be reported on a monthly or quarterly basis, Fig. 4. Such reports are not, as a rule, subject to close analysis and criticism by the customer. The format and contents are rather loose. The engineer reports the results which he thinks are of most interest. Since this is a formal report, quality of reproduction should be good.

Development—Test Report

Usually, a central test section conducts all engineering-development tests at the request of various engineering groups. If proper control is to be maintained, the test group should submit a monthly progress report to the engineering sections.

Format and Contents: Each test may be identified by a serial number and title. The report on each test should include such information as: 1. The responsible initiating engineers. 2. The responsible test engineer. 3. Estimated cost of the test, cost-to-date, starting date and scheduled completion date. 4. A brief summary of progress.

The development-test report is an internal progress report and economy is the objective. By careful planning, this report may be prepared by simply adding information to old masters each month.

Timing: The timely issuance of this report is most important both from a technical and a cost standpoint. Engineering labor costs are unlikely to rise rapidly unless a big recruiting program is undertaken. However, because of the equipment and outside contract work often necessary in development

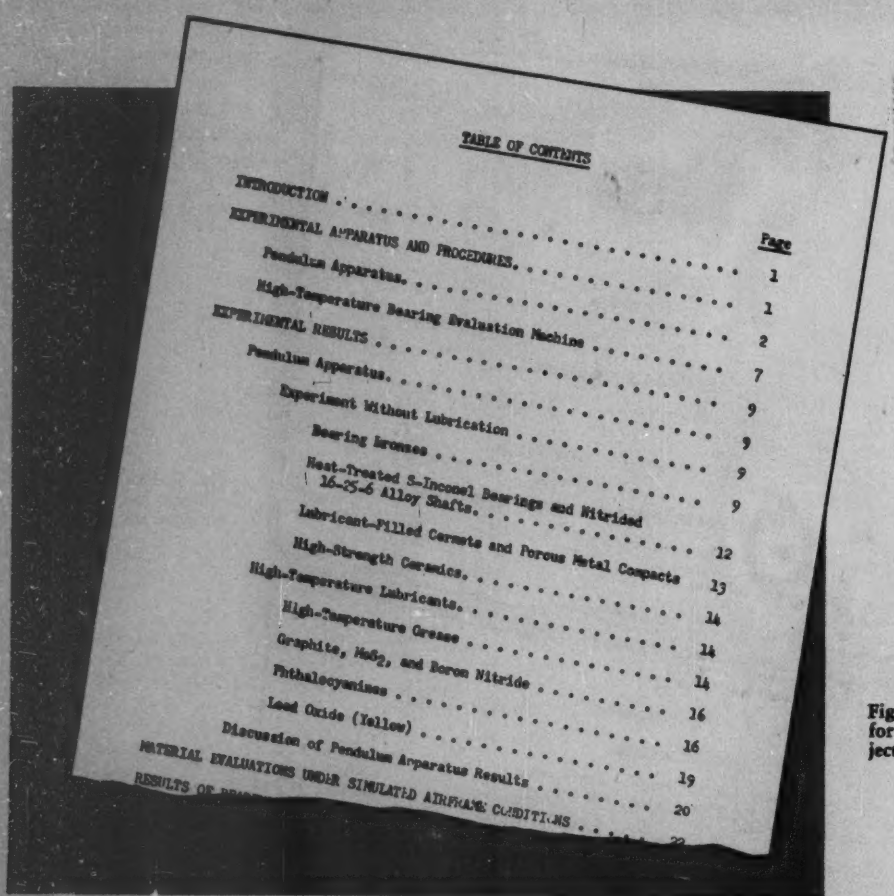

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Fig. 4—Table of contents for typical terminal project progress report.

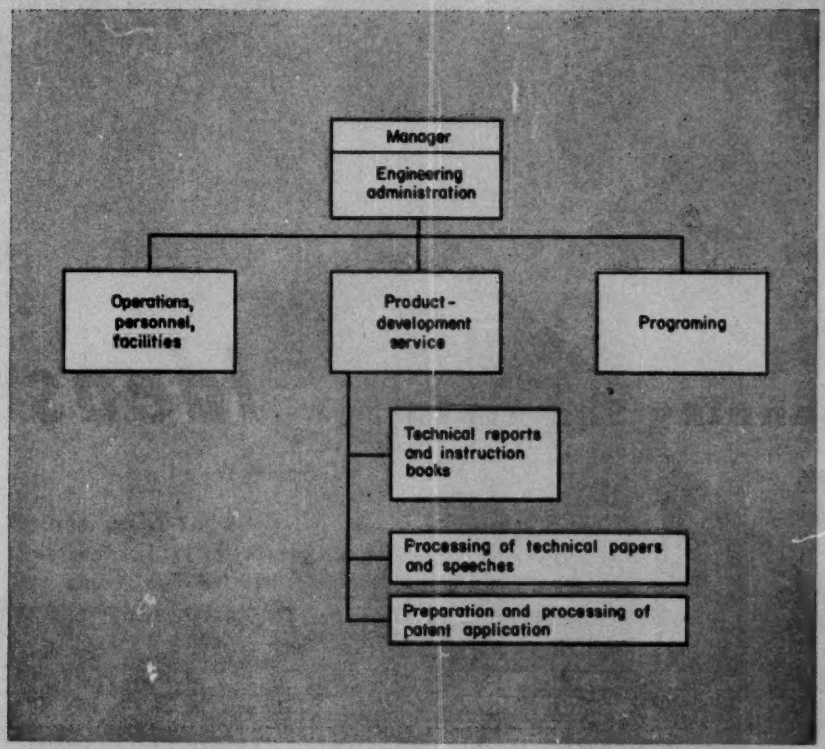


Fig. 5—Technical-publications setup for central handling of reports.

tests, costs may get out of hand within a few months unless careful control is exerted.

Summary Business Report

There are numerous ways in which the general manager or laboratory manager can be kept abreast of what is going on in the plant or laboratory: Staff meetings, memos, letters, special reports, and informal contacts. However, it is always a good idea for each manager on the general manager's staff to prepare a one to three-page monthly summary of activities and problems in his organization. This gives each manager a chance to air his accomplishments. At the same time, the general manager and his staff can get a good over-all view of the operation. Such a report may be circulated to company officers.

Terminal Project Progress Report

The terminal report at the conclusion of a major project should be a technical report, not a cost and schedule review. People may forget, after a time, how much they paid, but they never forget how good or bad the product is.

The terminal report should clearly delineate the original goals and the final accomplishments. Development problems and their solutions should be shown. Assembly drawings of major equipment, illustrative artwork, and adequate tables and graphs should back up the technical story. For a large project, this terminal technical report may require several volumes. Reproduction should be of high quality.

Technical-Report Section

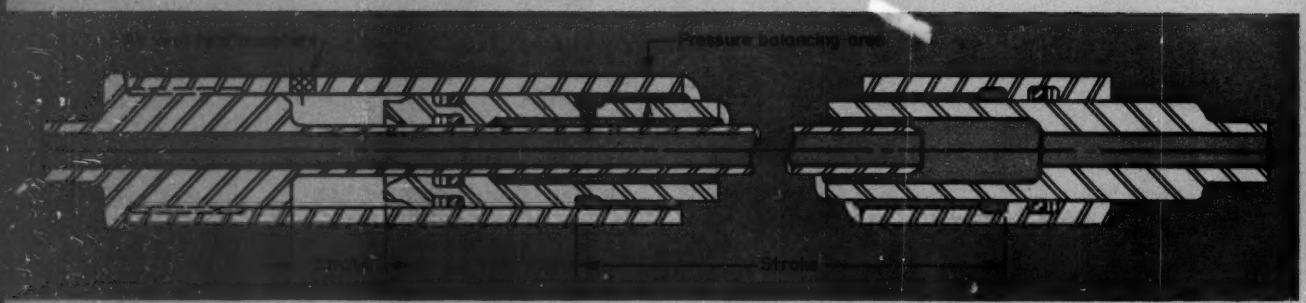
It is a mistake to assign an engineer part-time responsibility for getting out various engineering reports. Skill, talent, and experience are required to outline, edit, schedule, co-ordinate, and reproduce a good report. The preparation of reports requires at least one full-time professional, even for a small laboratory.

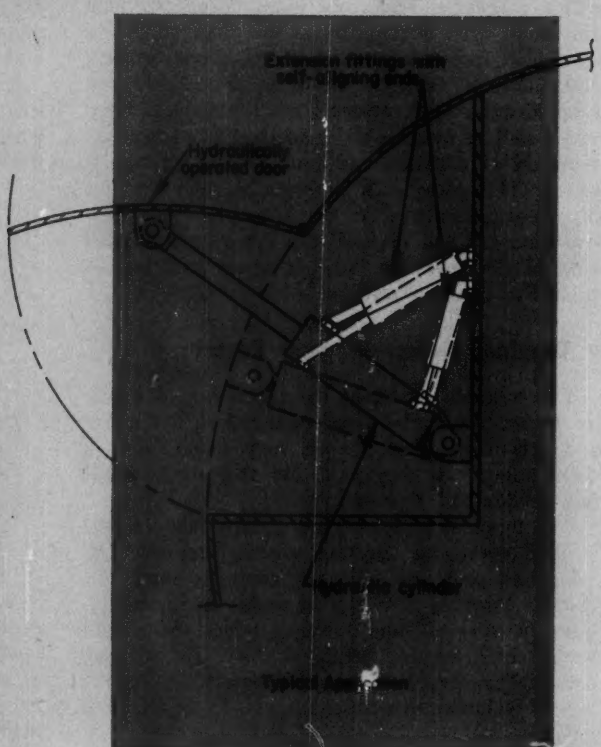
In an adequate report organization, most of the following functions should be performed by company personnel. Graphics and reproduction may have to be sent out.

1. **Co-ordination and planning:** Report outlines, evaluation of necessity for and frequency of reports, determination of quality, scheduling, accumulation of individual reports to make up progress reports, and production planning.
2. **Editing:** Checking at the technical level for content, clarity, and adherence to policies. Editing of language, grammar, and punctuation for final polish.
3. **Graphics:** Photography, technical illustration, drafting, and preparation of line drawings and graphs. Retouching and screening.
4. **Production and Followup:** Typing, typesetting, reproduction of illustrations, selection of covers for report, distribution, etc.

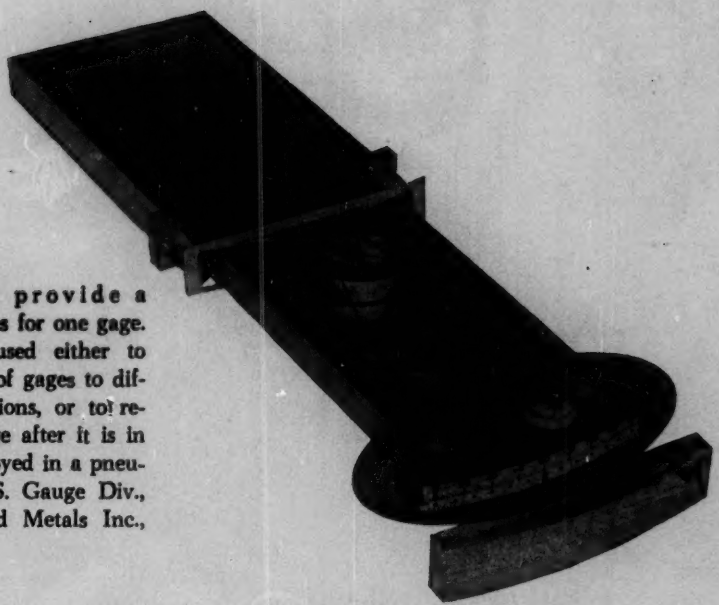
There is no one best way to set up a report center. Generally, central typing and production facilities are favored. Technical editors may be part of a Technical-Publications section of an Engineering-Administration group, Fig. 5, or assigned to the managers of large projects.

scanning the field for *ideas*

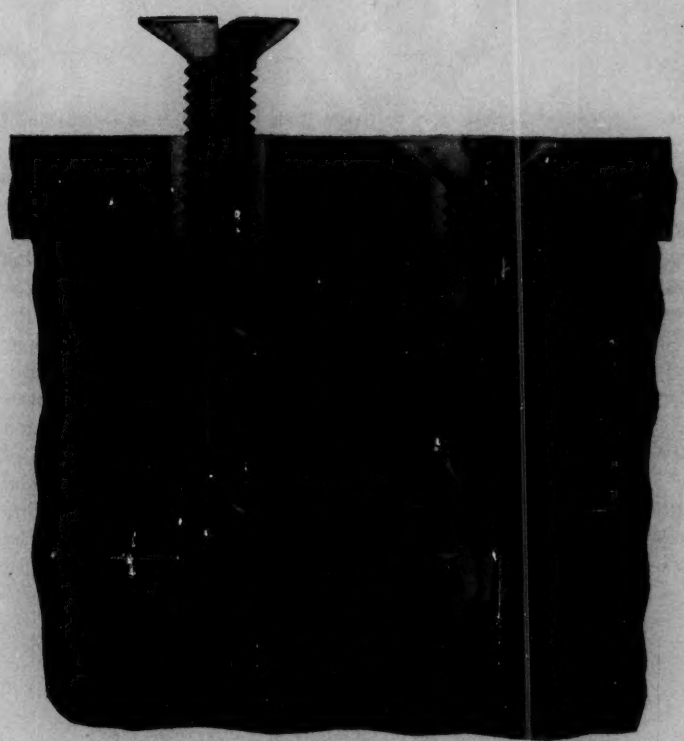




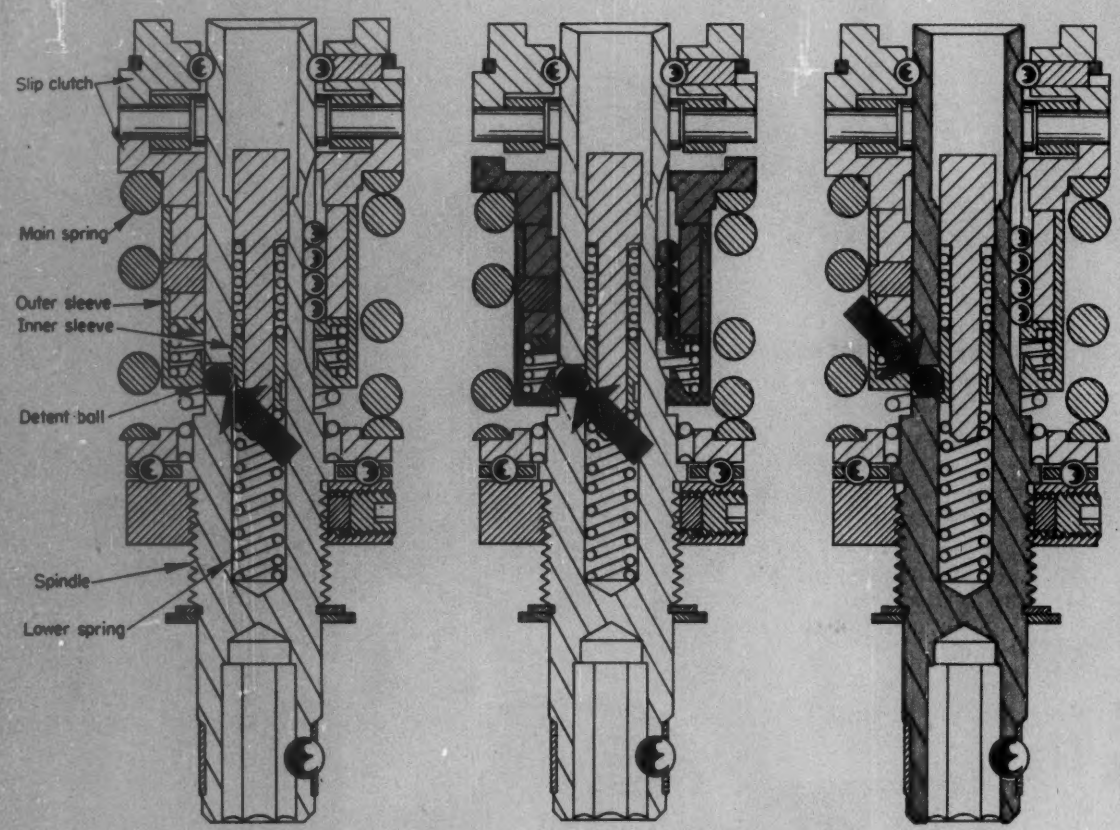
"Trombone" hydraulic fitting extends and retracts to change length during operation. Interconnection of the head and rod ends permit fluid flow, and balanced areas cancel out forces of the fluid pressure. When combined with self-aligning end fittings, the device can accommodate extension, rotation, and misalignment. Principle employed in a hydraulic fitting developed by Dumont Engineering Co., Long Beach, Calif.



Scales on a tape provide a quick choice of 20 scales for one gage. This choice can be used either to tailor each of a group of gages to different operating conditions, or to revise the use of the gage after it is in service. Principle employed in a pneumatic receiver by U. S. Gauge Div., American Machine and Metals Inc., Sellersville, Pa.

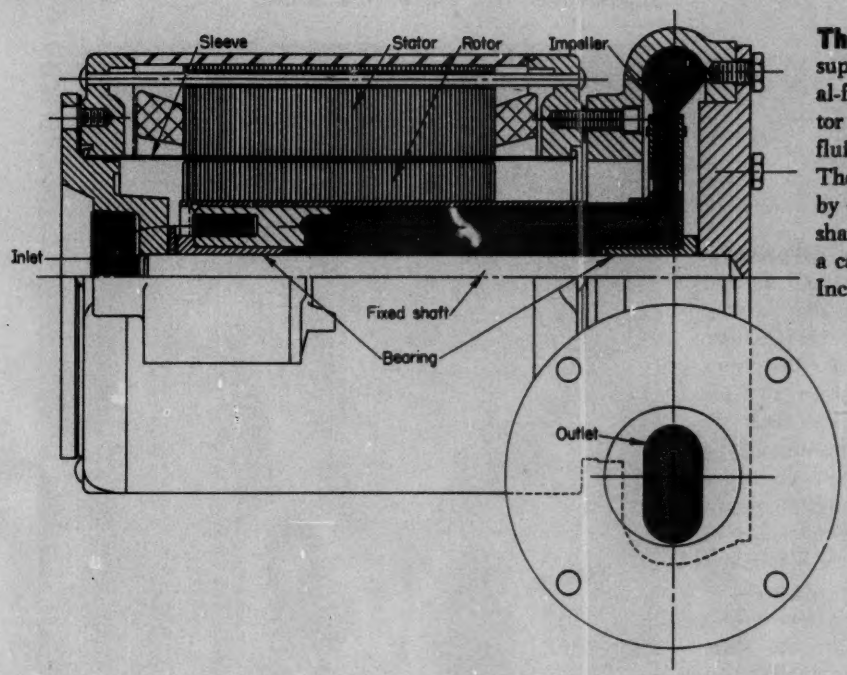


Nylon squeezes lead in an expansion-type fastener. When the screw is tightened, the force transmitted by the nylon ball drives a brass plug into the tapered end of the cylinder, and then extrudes the lead through slots in the cylinder walls. Resilience of the nylon ball acts as a locking device to resist loosening of the fastener by vibration. Principle employed in a fastener distributed by Douglas Kane Ltd., London, England.

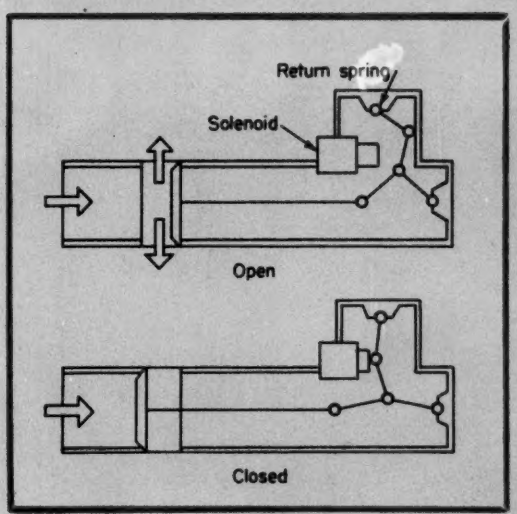


1. Normal Operating Configuration 2. Slip Clutch Held Open by Detent Balls 3. Detent Balls Released by Spindle

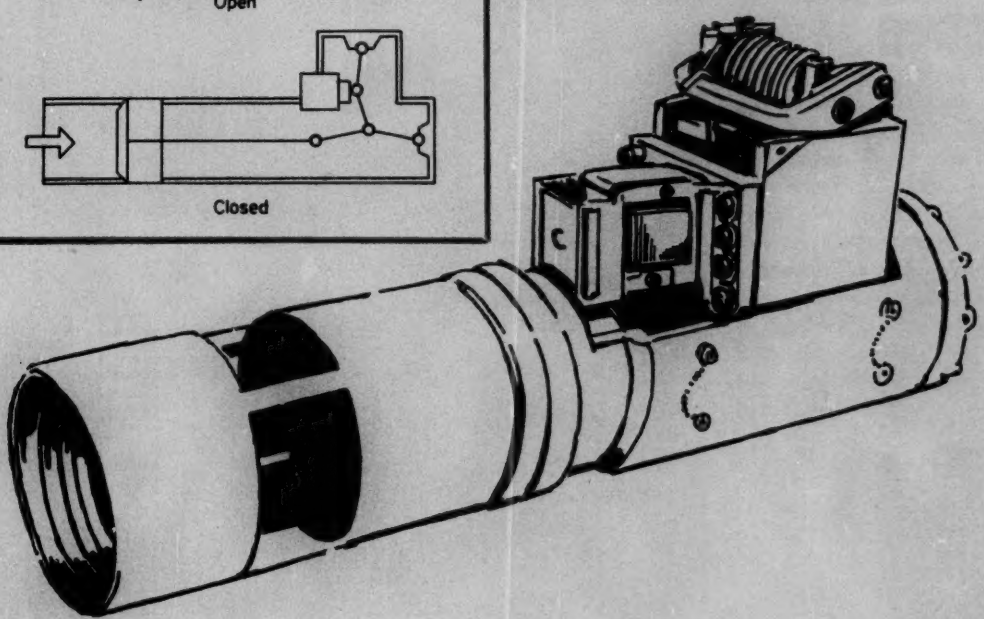
Groove-actuated balls control torque and motion of an air-driven wrench. When the torque required exceeds the preset value determined by the main spring, cam faces on the slip clutch force the outer sleeve downward. The detent balls are forced outward into the sleeve counterbore by the tapered groove in the spring-loaded inner sleeve. Thus, the slip clutch is held open and the wrench output stopped. When the wrench is removed from the work, the lower spring forces the spindle and the detent balls downward in relation to the inner sleeve. The detent balls then move into the groove of the inner sleeve, the spring-loaded outer sleeve returns to its original position. Thus, the control device is returned to its normal operating configuration. Principle employed in an air-driven torque wrench by Buckeye Tools Corp., Dayton, Ohio.



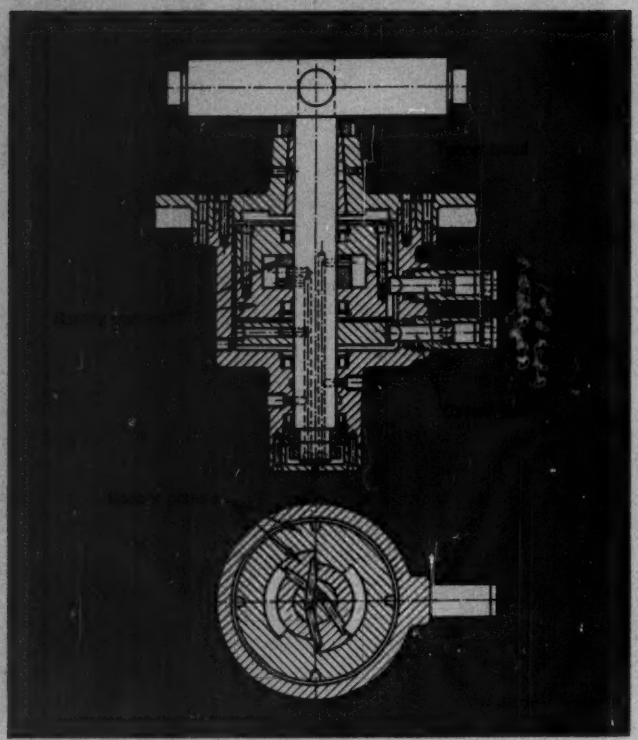
Through-rotor suction supplies the impeller of a radial-flow pump. The motor stator is protected from the pump fluid by a nonmagnetic sleeve. The hollow rotor, supported by open webs, turns on a fixed shaft. Principle employed in a canned pump by Corley Co. Inc., Boonton, N. J.

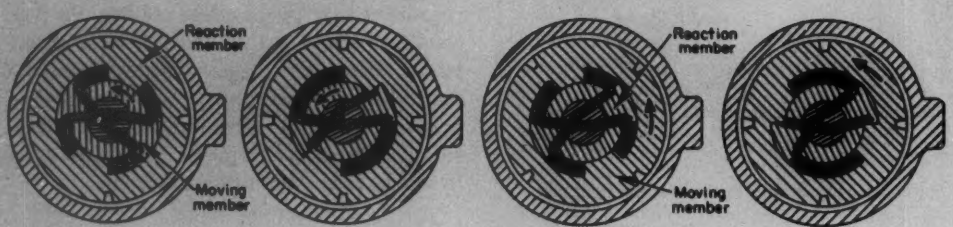


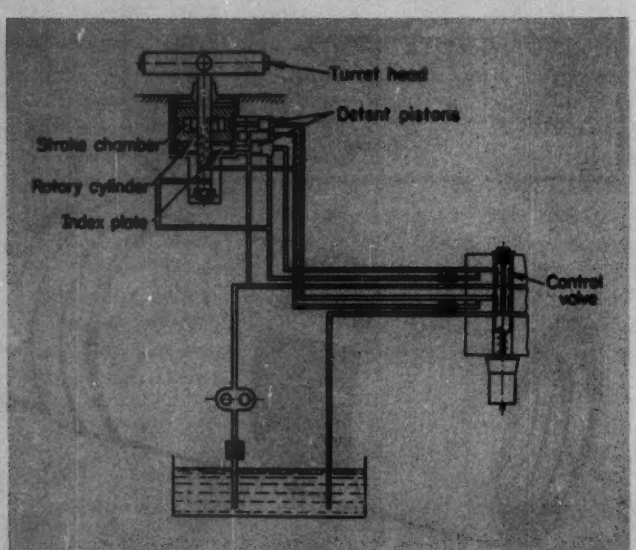
Toggle-controlled valve provides quick pressure release. In the closed position, the poppet valve is held against the seat by a spring-loaded, overcenter toggle linkage. To open, the linkage is tripped by a solenoid, and fluid pressure opens the valve within a few milliseconds. Principle employed in a valve by Research Inc., Minneapolis, Minn.

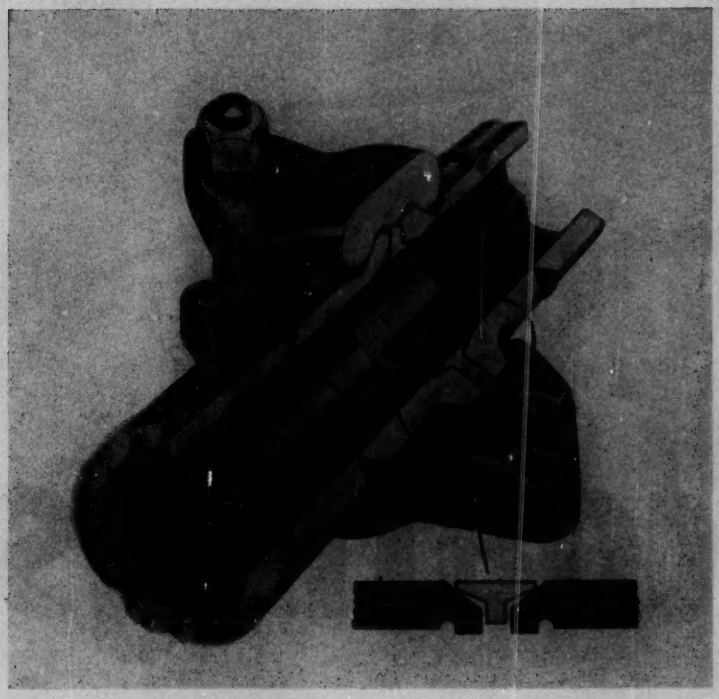


Rotary pistons alternate as reaction member and moving member in a hydraulic indexing motor. A detent, actuated by the pressure oil, holds the piston that is serving as a reaction member. After the detent stroke is completed, the pressure oil is ported to retract the opposite detent and then to power the rotary piston. When the control valve is reversed, this cycle is repeated for the opposite detents and piston. However, the rotary output motion continues in the same direction. Principle employed in an indexing table by Dr-Ing Boehme & Co., Minden/Westf, Germany.

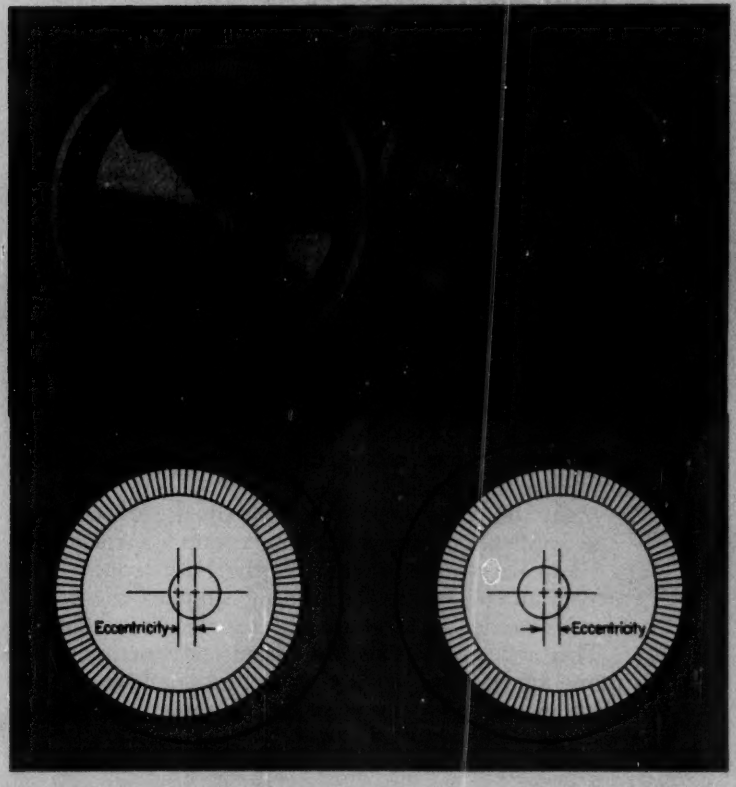








Deflected flanges seal a high-pressure pipe fitting. A slight difference in the angle of taper between the lips of the seal ring and the sealing surface of the mating hubs causes the seal ring lips to deflect as the hubs are brought together. Principle employed in a fitting by Gray Tool Co., Houston, Texas.



Eccentric serrated rings permit quick adjustment of radial position of a driven disc in relation to its driving disc. If the discs are positioned so that the eccentricity of the serrated rings cancel, the centerlines of the discs are aligned. If the driven disc is repositioned 180 deg, the maximum radial offset is produced. Intermediate offsets in 0.0001-in. increments can be obtained by partial rotation of the driven disc in relation to the driving disc. Principle employed in a tool holder by Wadell Equipment Co. Inc., Clark, N. J.

flame-sprayed coatings

. . . for parts exposed to

- **high temperatures**
- **erosion**
- **wear**
- **corrosion**

DEVELOPMENT of flame-sprayed coatings to upgrade base materials went into high gear just at the end of World War II. Commercial and military equipment requirements pushed materials to their limits in melting temperature and in resistance to erosion, wear, and corrosion. Today's space-vehicle needs continue to demand more and more performance from construction materials.

Many of these rigid requirements have been met by the application of metallic and ceramic surface coatings. The base material satisfies the bulk requirements of a component, while the coating supplies the special properties needed to meet stringent surface conditions.

This article describes four prominent methods used to flame spray these surface-protecting coatings. It also presents a guide to the selection of materials and the design of flame-sprayed parts.

a complete, four-section article covering the . . .

- ✓ Rod Method
- ✓ Detonation-Gun Method
- ✓ Powder Method
- ✓ Plasma Method

Circle 18-3 on Page 19 for extra copy.

✓ rod method

ROLAND J. WESTERHOLM
Product Engineer
Refractories Div.
Norton Co.
Worcester, Mass.

DEVELOPMENT of the patented Rokide process (rod method) of flame spraying was based on the theory that when the coating material is in rod form, the particles have to become fully molten before they are released.

The process uses compressed air to atomize the molten oxides and to project them at the work surface. The high velocity imparted to the oxides imbeds, flattens, and assures mechanical adherence of the particles on the prepared surface. The compressed air also helps cool the work parts, keeping them below 350 F.

Base Materials

Coatings applied by the rod method are not limited to specific base materials. These coatings can be sprayed on most rigid materials that can be adequately roughened by pressure blasting and that can be heated safely to 300 F.

Base materials that have been coated include:

Iron	Zinc
Steel	Molybdenum
Nickel-base alloys	Graphite carbon
	Ceramics
Aluminum	Glass
Brass	Wood
Titanium	Asbestos
Lead	Certain plastics

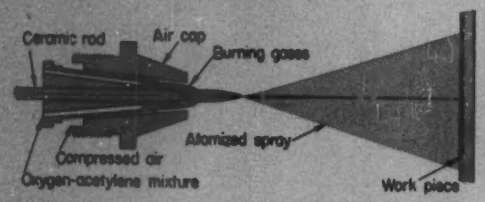
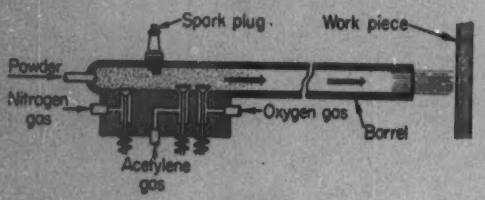
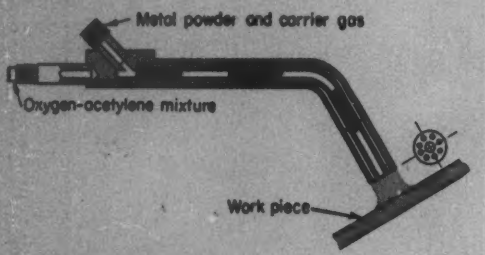
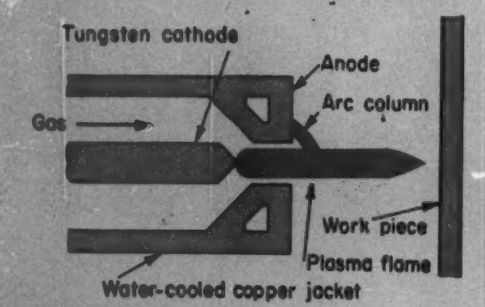
Surface Preparation: Surfaces that are to be coated must be absolutely clean and must be sufficiently roughened by grit blasting to offer maximum mechanical anchorage for the coating. Additionally, the coating must be applied soon after the roughening treatment. Roughening should be uniform and should provide a surface with as many re-entrant angles and sharp peaks as possible.

Aluminum-oxide abrasive grit or angular, chilled-

Photo, courtesy Reaction Motors Div., Thiokol Corp.

Manned X-15 research aircraft burns up more than half of its 16-ton starting weight in 80 sec. Zirconia coating, 0.025 in. thick, on thrust chamber, throat, and exhaust nozzle of XLR-99 engine protects these parts from temperatures of 4000 to 5000 F.

Table 1—Summary of Four Flame-Spray Methods

equipment	process	coating material
 **Rod Method** (Rokide), Norton Co.	A solid, ⅛ to ¼ in. diam ceramic rod (the coating material) is supported and centered in the special nozzle by three spring-loaded balls. The rod is mechanically fed into the oxy-acetylene flame at a controlled rate. Molten oxide particles from the rod are accelerated and propelled toward the workpiece at about 550 fps by compressed air (80 psi supply pressure).	Any ceramic or refractory material that melts (rather than sublimes) and forms droplets (rather than threads). Most work, however, has been done with aluminum oxide, zirconium oxide, zirconium silicate, chrome oxide, and magnesium aluminate.
 **Detonation-Gun Method** (Flame-Plating), Linde Co.	Controlled quantities of oxygen, acetylene, and suspended particles of coating material are admitted into the gun chamber. Detonation of the mixture by a spark heats the particles to a plastic condition and propels them at a supersonic velocity toward the workpiece.	Formulations of tungsten carbide with cobalt, nickel, or chromium-carbide additives, chromium carbide with a nickel-chromium additive, and aluminum oxide.
 **Powder Method** (Aircospray), Air Reduction Sales Co.	Powdered coating material, propelled by gravity and a carrier gas, is sprayed through the flame of a modified welding-type nozzle onto the workpiece. Fusion is accomplished by the torch flame which contacts the work. This process is also used for capillary brazing of joints.	Chromium-nickel and tungsten-carbide compositions with boron added.
 **Plasma Method** (Plasma-Plating), Linde Co.	A high-current electric arc is concentrated and stabilized in the controlled atmosphere of a special nozzle. Some of the gas (usually argon) flows through the arc where it is heated as high as 30,000 F and accelerated to supersonic speed. The gas forms a highly ionized plasma jet. Particles of coating material, in powder or wire form, are introduced into the plasma where they are melted, then accelerated to a high velocity toward the workpiece. The work is cooled by jets of CO_2 or air.	Tungsten, tantalum, molybdenum, aluminum oxide, and zirconium oxide.

iron grit may be used as the blasting medium. Fused aluminum oxide is preferable, especially for the softer substrates, because the iron grit may contaminate the surface and contribute to rusting and consequent poor adherence of the coating. Silicon carbide has also been found to be satisfactory as a blasting medium.

Undercoatings: Nickel-chromium and molybdenum undercoatings are sometimes used to improve: 1. Mechanical adherence. 2. Oxidation resistance. 3. Chemical resistance. 4. Thermal-shock resistance.

Nickel-chromium undercoatings (80 Ni, 20 Cr) have been especially successful in field applications. Molybdenum undercoatings on very hard materials that are difficult to grit blast and on graphite can increase speed of bonding as well as improve the quality of the bond.

Coating Materials

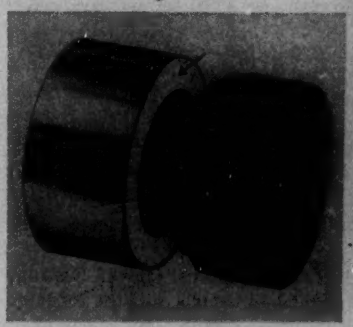
Almost any material which meets the following requirements can be applied as a coating: 1. It must melt rather than sublime (materials which dissociate may not produce a coating). 2. It must form droplets rather than threads (glass, for example, makes fibers rather than a coating).

Many materials meet these requirements. Tables 2 and 3 list the physical, mechanical, thermal, and dielectric properties of the five coating materials most commonly used.

It is sometimes necessary to build up the coatings into solid ceramic bodies to obtain their properties. Properties thus obtained must, therefore, be considered only as a guide to the characteristics of the materials as coatings. Properties may also vary with thickness of coating and may be influenced by the laminar structure of the coating.

Many other compounds and mixtures have been sprayed experimentally. These include such materials as fosterite, titania, nickel oxide, cerium oxide, and uranium oxide.

Mechanical seal ring for chemical pump is spray-coated with zirconium silicate (arrow) to resist highly corrosive operating conditions. The ground ceramic surface is used against a carbon gland, right, which imparts a self-lubricating effect by impregnating the zirconium-silicate coating.



Photo, courtesy Duralectric Corp.

Emissivity and insulating properties of sprayed alumina coating (striped areas) maintain sensitive electronic components of Explorer satellite at 50 to 86 F, despite orbital temperature range of −150 to +600 F.

Table 2—Physical and Mechanical Properties of Ceramic Coatings

Coating	Average Density (gm/cc)	Hardness* (Knoop Scale)	Porosity (per cent)	Compressive Strength, Ambient Temp. (1000 psi)	Adherence to Steel Approx. (psi)	Surface Finish† (mu in. rms)	Elongation‡ (per cent)
Aluminum Oxide	3.3	2000	8 to 12	37	600–1000	200 to 300 30 to 50 25 to 45	0.7
Zirconium Oxide	5.2	1000	8 to 12	21	600–1000	200 to 300 30 to 50 25 to 45	1.4
Zirconium Silicate	3.8	1000	8 to 12	..	600–1000	200 to 300 30 to 50 25 to 45	0.7
Chromium Oxide	4.6	....	4	105	...	200 to 300 15 to 25 10 to 20	1.3
Magnesium Aluminate	3.3	....	6	..	....	200 to 300 30 to 50 25 to 45	..

*Monolithic crystal.
†The three values shown are for "as-coated," "ground," and "lapped" surfaces.
‡For 0.020-in. thick coating.

Advantages: Standard coatings applied by the rod method have many specific features that contribute to their usefulness. They are:

- Highly refractory.
- Chemically inert to most corrosive gases and liquids.
- Good thermal and electrical insulators.
- Applicable in thicknesses up to ⅛ in.
- Extremely hard and erosion resistant.
- Applicable to a wide range of shapes and sizes and base materials.
- High melting point materials—from 3000 to 4500 F.
- Flexible, adherent, and lightweight.
- Able to provide controlled emissivity.

Limitations: Rod-applied oxide coatings are somewhat porous and do not provide complete protection against oxidation. However, for low-temperature applications, the coatings can be impregnated with various resins.

Coefficients of thermal expansion for the coatings are somewhat less than most metals, but the coatings do have a flexibility derived from the mechanical interlacing of particles. Gradated and laminar coatings further improve this property.

Composite Coatings: Composite spray coatings using plastic impregnants or integrated with metals can supply useful properties beyond those possible with the coatings alone.

Laminar coatings can improve thermal-shock and insulating characteristics, and integrated metal-ceramic coatings have revealed excellent thermal-shock and erosion resistance. Laminar coatings—alternate layers of sprayed metal and ceramic materials — have shown excellent results in rocket-blast shield experiments.

Gradated construction offers metal and ceramic coatings applied simultaneously in continuously varying proportions. These coatings achieve a gradation from all metal to all ceramic in accordance with a preselected pattern.

Impregnated coatings incorporate epoxy, phenolic, polyester, or silicone resins with the ceramic coatings. These impregnants contribute to the characteristics of the coatings by adding thermal and electrical insulation, ablation resistance, strength, thermal-shock resistance, and imperviousness. Use is limited, of course, to the temperature limitation of the resin. Penetration of ceramic coatings up to 0.030 in. has been achieved by capillary action of the various resins.

In a cyclic oxidation-corrosion test consisting of alternate cycles of 16-hr exposures at 950 F and 32-hr exposures to salt spray, an alumina coating, impregnated with a silicone resin, withstood a total of 600 hr of these alternating conditions without a noticeable effect on the coatings.

Design

Parts of almost any size and configuration can be coated by this method. The limiting factor is often the physical equipment for handling the part. A limitation exists, for example, on the smallest ID that can be coated because of the space needed for internal spraying. Pieces having holes less than 2 in. in diameter and greater than 2 in. in length are diffi-

Table 3—Electrical and Thermal Properties of Ceramic Coatings

Coating	Electrical Conductivity	Electrical Resistivity (ohm-in.)	Dielectric Constant at 1000 cps, 0 to 600 F	Dissipation Factor at 1000 cps, 0 to 600 F	Loss Factor at 1000 cps	Melting Temp (F)	Specific Heat (Btu/lb/deg F)	Coefficient of Expansion (per deg F)	Thermal Conductivity (Btu/hr/sq ft/-deg F/in.)	Emissivity Coefficient†
Aluminum Oxide	Nonconductor	4.5×10^{8} (500 F) 1.2×10^{8} (800 F)	10	0.05	0.5	3600	0.28 (90 to 3100 F)	4.1×10^{-6} (70 to 2250 F)	19 (1000 to 2000 F)	0.8 (200 C) 0.5 (800 C) 0.4 (1000 C)
Zirconium Oxide	Nonconductor*	2.7×10^{4} (500 F) 2.1×10^{3} (800 F)	35	0.15	5.25	4500	0.175 (80 to 2550 F)	5.4×10^{-6} (70 to 2250 F)	8 (1000 to 2000 F)	0.7 (200 C) 0.4 (800 C) 0.34 (1000 C)
Zirconium Silicate	Nonconductor	1.1×10^{6} (500 F) 4×10^{3} (800 F)	15	0.08	1.20	3000	0.15 (est.)	4.2×10^{-6} (70 to 1100 F)	15 (1000 to 2000 F)	.....
Chromium Oxide	Nonconductor	.....	..	...	...	3000	0.2 (60 to 2700 F)	5.0×10^{-6} (70 to 2000 F)	18 (est.) (1000 to 2000 F)	0.9 (200 C) 0.75 (1000 C)
Magnesium Aluminate	Nonconductor	.....	..	...	...	3500	0.25 (70 to 1832 F)	4.5×10^{-6} (70 to 2000 F)	18	.....

*Ambient temperature rating. Conductivity increases rapidly above 1200 C.
†Emissivity from total hemisphere, from a coating approximately 0.030 in. thick.

cult to coat uniformly.

Wherever possible, the coating procedure is automated. If a manually applied coating is necessary, tolerances of ±0.003 in. can be met. Closer coating limits can be produced by grinding.

Thickness: Ceramic coatings can be sprayed in thicknesses of 0.003 to over 0.125 in. Coatings under 0.003 in. are not recommended because of the difficulty in maintaining uniformity. As coating thickness increases, however, the effects of thermal and mechanical shock to the coating also increase.

The rate of coating lay-down depends somewhat on the configuration of the piece. Generally, one ¼-in. diam alumina rod, 24 in. long, will cover 60 to 65 sq in. of surface, 0.010 in. thick, in 4 min.

Applications

Coating selection for an application depends on whether the needs are primarily for thermal insulation, wear resistance, corrosion resistance, electrical insulation, or for a fastening medium.

Alumina and zirconia are used predominantly in the missile field. Alumina offers the advantages of a hard, gas-erosion-resistant material for high-temperature resistance. It has good insulation properties and is economical. In the commercial field, these same properties are useful on printing rolls, buffing fixtures, and mechanical seals.

Zirconia, with a higher melting-temperature than alumina, offers good resistance to thermal and mechanical shock. Zirconia coatings successfully protect ramjet and rocket components from hot, high-velocity, corrosive gases. In the industrial field, zirconia has extended the life of annealing and normalizing rolls, anode molds, and furnace tubes.

Zirconium silicate, with its glassy phase matrix, has found usage in many wear-resistant applications such as pump shafts, mechanical seals, and paper-machinery rotors.

Chrome oxide, a relatively new coating, has been successful as a wear-resistant material. It is a dense, black coating with only 4 per cent porosity, capable of being ground to fine surface finishes on the order of 10 mu in. rms. It outperforms many hard-facing materials on applications such as capstan wheels and thread guides.

Magnesium aluminate (spinel) is a new coating material that shows promise in the metal-melting field. As economical as alumina, magnesium aluminate provides some of the additional inert features of magnesium that have been difficult to incorporate in coating systems.

detonation-gun method

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FLAME-PLATING (detonation or D-gun method) is a patented process used to upgrade standard materials with coatings of tough, wear-resistant compounds—both metallic and nonmetallic. In the process, measured quantities of fuel and particles of coating material are detonated in a specially constructed gun, somewhat resembling a machine gun, Table 1. The molten particles are blasted from the gun and imbedded into the surface of the workpiece where a microscopic welding action produces a tenacious bond at the interface. Successive detonations build up the coating material to the required thickness.

Because of the noise of the process, the gun is isolated by double concrete walls insulated with sound-absorbing materials. Aiming and firing is remotely controlled from a panel outside the firing chamber.

Coatings can be applied as needed on selected areas of the base material. Warpage, distortion, or other physical change in precision parts is minimized because of the low temperature maintained in the base material during plating. Although temperatures above 6000 F are reached within the gun, the part temperature is maintained below 400 F.

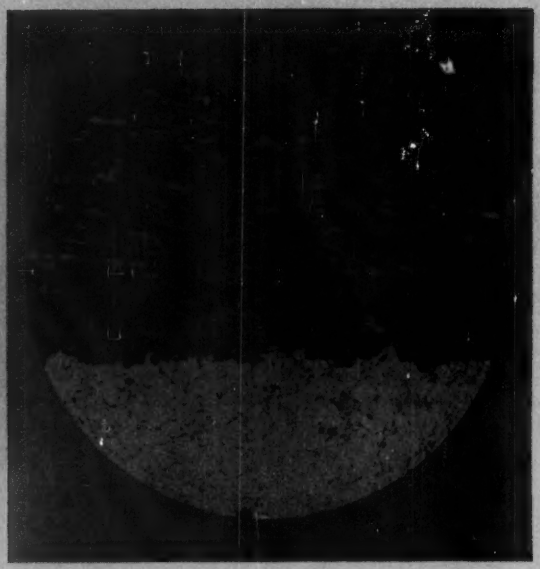
Base Materials

Materials that can be plated by the D-gun method include steel, cast iron, aluminum, nickel, copper, titanium, magnesium, and various alloys. However, the hardness and thickness of the base material must be sufficient to resist permanent deformation under the load and stress encountered.

In many cases, the material previously used for an application can be retained and its surface upgraded with the coating. If close tolerances must be maintained, the surface can be machined to compensate for the coating thickness. In many instances, a less expensive, more machinable (or otherwise more desirable) material can be substituted for the original.

Most parts are prepared for plating by grit blasting with fine-grain aluminum oxide. The purpose

Hard, 0.004-in. thick tungsten-carbide coating on jaws of stainless-steel surgical-needle holder provides positive grip and minimizes needle rotation.



Photomicrograph shows the fine-grain, dense, laminar structure of a tungsten-carbide coating (dark area) applied to a mild-steel substrate. No voids or oxides are visible at the boundary layer.

of this operation is not so much to roughen the surface as it is to remove oxide films.

Coating Materials

Whether as-coated or finished, the coatings applied by the detonation-gun method, Table 4, have resistance to wear, abrasion, corrosion, and erosion, even under conditions of high temperature, high load, and lack of lubrication.

Conventional equipment and abrasives are used to refine the finish on the coatings. One common method involves precision diamond grinding or diamond grinding plus lapping; another, off-hand polishing with either diamond or silicon-carbide abrasives.

Ground and lapped coatings perform well under conditions of fretting corrosion. Finished coatings,

Table 4—Physical Properties of Detonation-Gun Coatings

Property	Coatings, Approximate Composition (per cent by weight)					
	WC, 6 to 8 Co	WC, 13 to 15 Co	WC, 15 to 17 Co	25 WC, 7 Ni, W-Cr carbides	85 Cr_3C_2, 15 Ni-Cr	99 + Al_2O_3 (gamma)
Hardness Vickers*	1200 to 1450	1100 to 1250	1050 to 1200	1000 to 1200	850	1000 to 1200
Max Operating Temperature in Oxidizing Atmosphere† (F)	1000	1000	1000	1400	1800	1200 to 1800‡
Coefficient of Thermal Expansion (per deg F)	4.0×10^{-6} (70 to 1000 F)	4.5×10^{-6} (70 to 1000 F)	4.7×10^{-6}	4.6×10^{-6} (70 to 1400 F)	6.4×10^{-6} (70 to 1800 F)	3.9×10^{-6} (70 to 1832 F)
Modulus of Rupture (1000 psi)	67 to 73	80 to 90	90 to 100	40	75	22
Modulus of Elasticity (10^6 psi)	40	36 to 38	34 to 36	17	22	16
Porosity (per cent)	0.5	0.5 to 1.0	0.7 to 1.2	0.5	0.5	0.1
Specific Gravity	14.2	13.4	13.2	10.1	6.54	3.45
Specific Heat (Btu/lb/deg F)	0.048	0.054	0.056	0.070	0.127	0.196
Thermal Conductivity (Btu/hr/sq ft/deg F/ft)	5.3 (70 to 500 F)	5.3 (70 to 500 F)	5.3 (70 to 500 F)	3.8 (at 500 F)	4.3 (at 500 F)	0.86 (at 500 F)
Remarks	High wear resistance.	Excellent wear resistance, good resistance to mechanical and thermal shock.	Excellent wear resistance, best resistance to mechanical and thermal shock.	Excellent wear resistance at elevated temperatures. Good corrosion resistance.	Good wear resistance at high temperatures or in corrosive media. Resists flame impingement.	Excellent resistance to wear, chemical attack, and high-temperature deterioration.

*Load on diamond pyramid, 300 gm.
†For short durations, considerably higher temperatures can be tolerated in many atmospheres. For example, the coating described in the first column will resist flame impingement at temperatures up to 4000 F for several minutes.
‡Maximum operating temperature for aluminum oxide coatings is highly dependent upon base metals used and nature of service.

when mated with proper materials, generally have lower coefficients of friction than most metal-to-metal combinations. Porosity of these coatings is less than 1 per cent. As-coated surface smoothness is approximately 150 mu in. rms which can be finished to less than 1 mu in.

Design

Coatings can be applied in thicknesses from 0.0005 to more than 0.010 in. Areas which allow the particles free access are plated evenly, but small holes, blind cavities, and deep V-shaped grooves present processing difficulties and should be avoided.

Corners and edges should be free of burrs. Whether corners should be left sharp, radiused, or chamfered prior to plating depends on how sharp the corners must be after the coating has been applied. Where it is necessary to wrap the coating around an edge, a minimum radius of 0.015 in. is required.

Sizes and shapes of parts which have been plated are:

- Long cylindrical parts: 0.2 to 28 in. diam by 102 in. long.
- Short cylindrical parts: 0.2 to 90 in. diam by 6 in. long.
- Internal diameters, greater than 0.38 in., open at both ends; Plating depth is limited to 1½ times diameter.
- Rectangular flat surfaces: 60 by 102 in.
- Circular flat surfaces: 0.1 to 90 in. diam.
- Weight limit: 1000 lb.

Generally, the cost of detonation-gun plating is greater than methods such as nitriding or chrome plating, but for most applications, the additional cost is balanced by increased service life, increased production (fewer rejects), and decreased down-time of equipment. Since the coatings can be stripped and the parts replated, replacement expense is low.

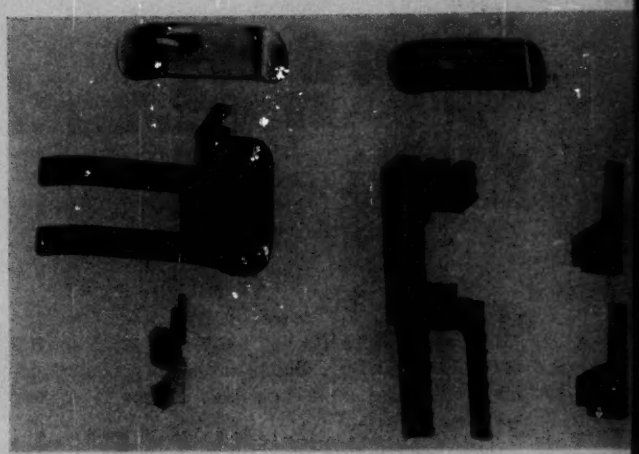
Applications

D-gun coatings are used in many industries. For example, during the development of a turboprop engine, a severe fretting-corrosion problem was encountered in the sleeve bearings of a torque-meter shaft. The best life obtainable with conventional heat-treating methods was only 50 hr. Both of the two preliminary solutions—carbide sleeve inserts, or a complete redesign of the bearings—added weight to the unit. Ultimately, the bearing surfaces were plated with tungsten carbide by the D-gun process. Life was increased to over 1500 hr without any additional weight.

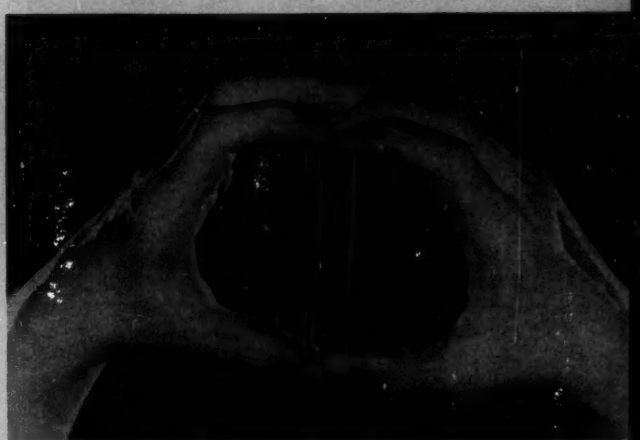
D-gun-plated plug and ring gages have many advantages. Wear resistance is excellent, and edge chipping and breakage are minimized. Additionally, the gages can be made of the identical metal that is being gaged. Thus, the two parts have the same coefficient of expansion, and the need for a constant-temperature room is eliminated.

Tungsten-carbide coatings solve wear problems on automatic knife sharpeners of cloth-cutting machines. The power-grinding operation is performed by two emery stones that move over the length of the oscillating knife edge. If guided improperly, uneven blade wear and the wrong width of bevel on the knife edge result. The tool-steel guides formerly used to insure proper sharpening action lasted about two months before being worn beyond allowable tolerances. Present D-gun-coated guides provide an average life of one year.

Many applications of these coatings involve cutting edges that are subjected to intense wear, such as pineapple-cutting knives, skiving knives for rub-



Tungsten-carbide plating of gripper dogs in metal-strapping tools increased life fivefold over hardened steel dogs. Coating is 0.002 in. thick.



Grinding samples show four stages of finish on tungsten carbide coating. From left to right, as-coated finish, 125 to 150 mu in. rms; polished with 80-grit rubber silicon-carbide abrasive, 50 to 75 mu in. rms; ground only with 220 grit diamond wheel, 8 to 10 mu in. rms; ground with 220 grit diamond wheel and lapped with number 3 diamond abrasive, 1 to 1.5 mu in. rms.

ber and plastic, and tubular drills for cutting acoustical tile and paper. In the canning industry, seaming chucks, coated with abrasion-resistant tungsten carbide, have a life over four times that of the uncoated parts.

In other fields, sintered-metal coring rods, valve surfaces, fishing reels, turbine-engine seals, cold-forming dies, anvil blocks, and wire-forming mandrels utilize the advantages of these wear-resistant coatings.

powder method

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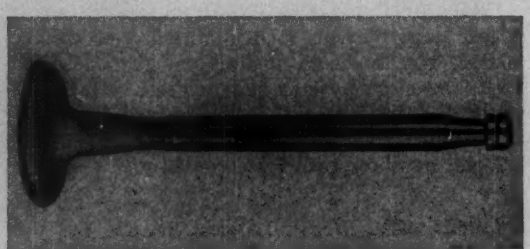
THE Aircospray (powder-spray) process was developed expressly for hardfacing and brazing operations in which molten or heated powder metals are sprayed on a base metal through an oxyacetylene flame.

This method uses a standard oxyacetylene welding outfit with a modified tip which permits the powder metal to be sprayed through the flame, Table I. A carrier gas—argon, helium, nitrogen, or carbon dioxide—conveys the powdered metals to the torch tip. The fuel gas can be acetylene or hydrogen.

The primary use of the process is to deposit and simultaneously fuse powder metals on a base metal. In other cases, an incompletely bonded coating can be fused to an underlying metal surface in a subsequent heating operation. Thirdly, the powder-spray method can be used for brazing. This discussion concentrates on the first two functions only.

Hardfacing coating of tungsten carbide and chromium is used on agricultural equipment like thrasher teeth for protection from earth-abrasion conditions. Coating thickness is usually about 0.010 in.



Alloy coating of nickel, chromium, and boron on diesel valve seat provides hard, corrosion-resistant surface with low coefficient of friction.

Materials

Preparation of the metal surfaces to receive the powder-metal deposits is of great importance. Surfaces must be free of oil, grease, oxides, and other contaminants. In addition, the surface to be overlaid should be roughened by machining, grit-blasting, or other abrasive preparation. For best results all sharp corners and edges should be rounded slightly.

Generally, powdered alloys used for fused coatings are hardfacing metals—basically chromium-nickel compositions to which boron has been added. Other additives such as silicon and phosphorus are sometimes used.

The screen-mesh size of the powder-metals must be within the limits of −80/+100. The uniform emission of coating materials by this process yields depositions down to 0.003 in. thick.

Design

One of the important applications of the powder-spray method is that of depositing and simultaneously fusing powdered metals in narrow bands, such as on a thin edge. The coating is deposited just ahead of the torch flame, which then immediately fuses the coating to the surface. Deposits as heavy as 0.070 in. can be made in a single pass. When heavier deposits are required, a second pass is recommended. Dimensional tolerances in the range of plus or minus 0.003 to 0.005 in. can be held.

When the powder metals are to be deposited for subsequent fusing, the coating material must be put down carefully on the base metal without flowing, sagging, or pulling away from the edges.

Alloys with wide ranges of plasticity allow such deposits up to about 0.070 in. thick. The sprayed coatings are then fused to the base material.

For large parts, preheating to 200 to 300 F is often specified to prevent rapid cooling of the surface being coated. However, since the surface of the part may become oxidized, a thin layer of powder metal—0.003 to 0.005 in. thick—should be deposited before the part is preheated. The thin layer then can be fused and any subsequent layers can be applied in the usual manner.

If the powder metals are applied to cold parts, fusion of the coating should follow the spraying as soon as possible to minimize cracking of the coating.

Recommended grinding allowances for these hard-surfaced parts are: 1. For workpieces up to 2 in. diam, 0.010 to 0.020 in. 2. For workpieces up to 6 in. diam, 0.020 to 0.030 in.

In addition to allowances for grinding, approximately 20 per cent should be allowed for shrinkage of the metal deposit.

plasma method

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PLASMA-PLATING is a patented companion process to Flame-Plating. It is used to upgrade standard materials with coatings of exotic metals, refractory compounds, and other substances. In this process, no combustion takes place; the flame consists of a jet of highly ionized, heated gas (plasma), produced by an electric arc, Table I.

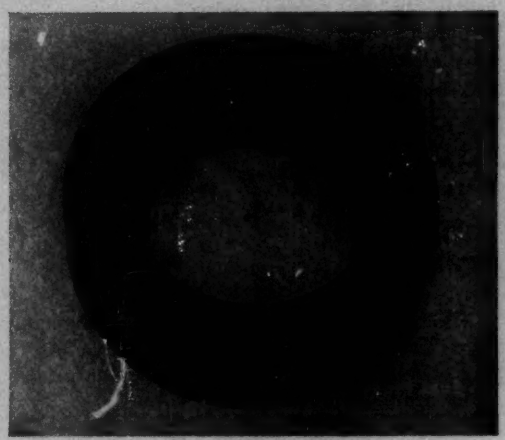
Two basic types of the plasma-jet device are currently used. In one, the arc leaves the nozzle of the torch and is transferred along with the gas stream to the workpiece. This is the basis for metal-cutting. In the second type, the arc is forced into and through the nozzle by the gas flow, but it ends on the nozzle while the gas continues to flow to the work. This is the nontransferred arc device—the basis for the Plasma-Plating process.

Materials

Almost any base material—even certain reinforced plastics—can be coated. Metal surfaces to be plated are often prepared by a grit-blasting operation which removes oxide films from the part. The abrasive usually used is aluminum oxide.

Any inorganic solid that melts without decomposition can be used as a coating material. Many basic coatings have already been established, Table 1, and other coatings of oxides and refractory metals are being developed.

Because plasma coatings can be deposited in practically any desired thickness, entire parts can be fabricated by this method. The required thickness is built up on a mandrel formed to the internal shape of the finished part, then the mandrel is removed chemically. Thus, intricate shapes can be made of materials which are normally difficult to fabricate.



Tungsten insert, 0.060 in. thick, in graphite rocket nozzle resists erosion of high-temperature, high-velocity exhaust gases.

Rocket blast-tube liner is fabricated by applying 0.045 in. thick tungsten on a mandrel which is then removed chemically. Diameter at large end is 2.4 in.

In the as-coated state, tungsten parts have a

density of 87 to 90 per cent of theoretical density, a modulus of rupture of 50,000 psi, and a Young's modulus of 24 × 10^6 psi. Heat treating increases the coating density to from 92 to 96 per cent, the modulus of rupture to 70,000 psi, and the modulus to 44 × 10^6 psi. Standard equipment and methods can be used to grind, lap, or polish the coatings when fine surface finishes are required.

Design

Only those areas which allow the particles of coating material sufficient access can be plated evenly by the plasma process. Consequently, for uniform coatings, shapes of parts or mandrels to be plated are limited to surfaces of revolution or contours that deviate no more than 45 deg from the axis of revolution. However, more extreme asymmetrical shapes can be coated with hand-operated equipment if somewhat less uniform coating thicknesses can be tolerated.

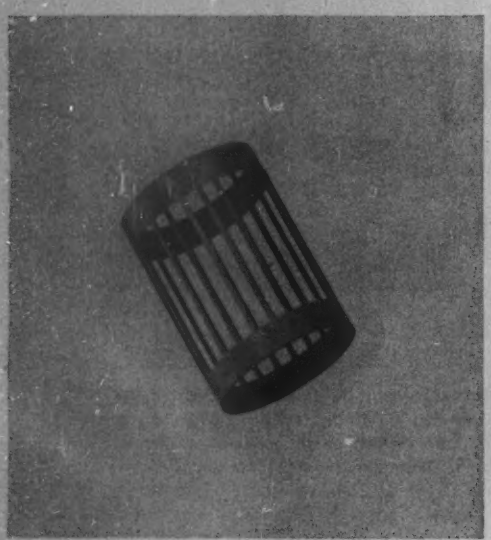
Applications

Plasma-plated parts are used in many applications where thermal and electrical insulation, thermal-radiation shielding, and where refractory properties are important.

A prominent application is that of nozzle inserts for solid-propellant rocket engines, where flame temperatures of 5000 to 6200 F are encountered. The erosive effects of the high-velocity gas (usually over 5000 fps) at high temperatures, plus the burden of solid particles and possible reactive by-products, present a particularly severe problem in the design of a nozzle which must remain dimensionally stable throughout the designed firing cycle.

Graphite materials are used for rocket nozzles because of their high-temperature structural strengths and other properties. But these materials lack adequate erosion resistance to meet service conditions. Various high-melting-temperature materials offering better erosion resistance have been tried as coatings on graphite. Pure tungsten has emerged as the most effective material for service up to 6000 F. Tungsten—alone, or with an undercoat such as tantalum—can be applied by the plasma process to any grade of graphite. Mechanical bond strength is equal to the strength of the graphite.

Another area of application for plasma coatings is in the production of refractory components—parts such as crucibles for high-melting-temperature materials. These parts are structurally sound, dense, and can be made with high surface finishes. Crucible wall thicknesses of the order of 0.040 to 0.060 in. can be formed in shapes other than simple cylindrical forms.



Tungsten grid gage illustrates complexity of parts that can be fabricated by the plasma process. Wall thickness of cage, used in large vacuum tube, is 0.030 in.

Tips and Techniques

Cutting Magazine Pages

Removing pages from magazines by means of a penknife or scissors is frequently unhandy. A better method is to use a serrated wallpaper cutting wheel, such as the Sears-Roebuck "Workmaster," to perforate the pages. The necessary pages can then be neatly torn out.—W. B. Conover, *Defense Electronics Div., General Electric Co., Pittsfield, Mass.* [Or use the handy cards on page 19—Ed.]

Interpolating Tabulated Functions

In *Tips and Techniques*, August 3, 1961, Page 96, the first and last equations should be in the form

$$F = (1 - k)T + kL$$

and

$$L = (1 - k)f(x_0) + kf(x_1)$$

where $f(x_0)$ and $f(x_1)$ are the values of the function on either side of the required interpolated value.

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, Machine Design, Penton Bldg., Cleveland 13, O.

Hydraulic Pumps and Motors

Part 2—Predicting performance in systems

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Department of Engineering
Harvey Mudd College
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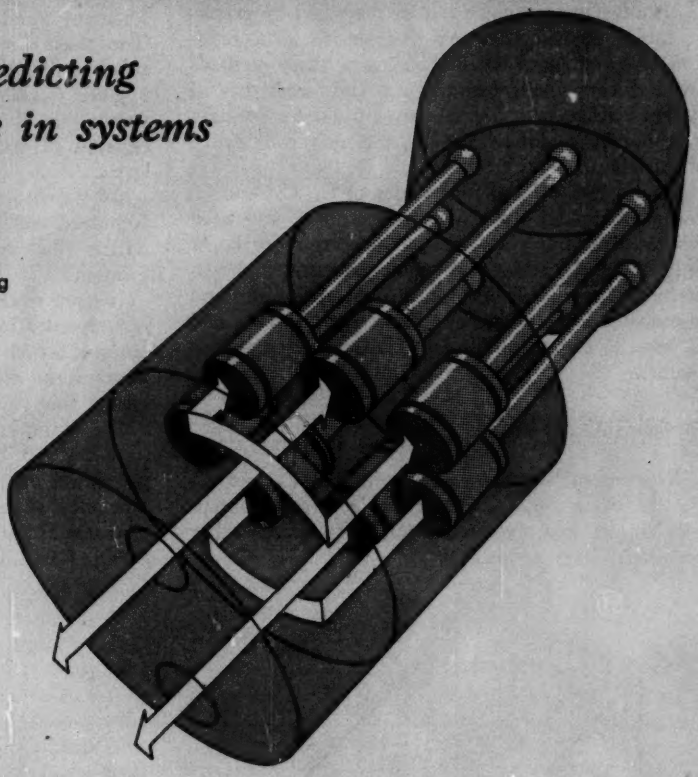

Pump and motor performance can be predicted from basic equations. The performance coefficients used in these equations can be obtained experimentally, or assumed on the basis of the state of the art. However, interaction of the components will be determined by the system design. This interaction can be described by the equations of mechanics and conservation of mass.

EFFECTS of variations in speed, pressure, and fluid viscosity must be considered in selecting the individual components for use in a hydraulic system. If off-the-shelf items are used, their performance capabilities must be evaluated. If new components are to be designed, their performance must be predicted and expressed in usable terms. This article presents a method for expressing speed, pressure, and viscosity in terms of the nondimensional performance coefficients as explained in Part 1 of this series (Aug. 17, 1961, pp. 138-142), and then using these coefficients as selection guides.

● Basic Relationships

Pump performance can be expressed by

$$Q = DN - \frac{C_s \Delta p D}{2\pi\mu} \qquad (1)$$

and

$$T = \frac{(1 + C_l)\Delta p D}{2\pi} + C_d D \mu N \qquad (2)$$

For fluid motors, the signs shown in the right hand side of Equations 1 and 2 are reversed.

This linear theory of pump and motor perform-

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ance is not completely accurate, since the coefficients are not absolute constants. However, for many purposes it will predict performance with sufficient accuracy and reliability.

Although performance can be described by graphs or tables showing delivery and torque as a function of speed, pressure, and viscosity, these methods are not convenient for analysis and prediction of system performance. Furthermore, the necessary data may not be available over a sufficiently wide range of variables.

On the other hand, the values of C_s, C_d, and C_f can be obtained from very meager data and used for cautious extrapolation. It is necessary to know only the peak efficiency; speed, pressure, and viscosity at zero delivery; and speed, pressure, and viscosity at peak efficiency. From these, C_s, C_d, and C_f can be computed for any off-the-shelf pump or motor.

Coefficient Values

Experimentally determined values of C_s and C_d are shown in Fig. 1. One group represents pumps and motors manufactured prior to 1950; the other represents current models.

The broken lines of constant values of clearance-radius ratio are the lines on which the points would fall if the theory of flow through small passages were completely adequate to describe the performance of pumps and motors.

During the decade 1950-1960, the slip flow, as indicated by lower values of C_s, has been reduced for many pumps, but C_d has increased in most cases. The need for operating at higher pressures has required designs which have lower values of C_s. For a given C_s, higher pressures and higher speeds are compatible if the pump or motor is structurally capable of withstanding the higher pressure and speed.

As shown in Fig. 1, three current models have combined coefficients C_sC_d better than 0.001. None of the 1950 and earlier models attained such performance.

In some cases, desirable (small) values of C_sC_d are accompanied by large values of C_f. Tight fits between surfaces which experience relative motion result in poor overall efficiency although the volumetric efficiency may be excellent.

For example, the pump shown in Fig. 1 with $C_s = 2.2 \times 10^{-10}$ and $C_d = 10^5$ has $C_f = 0.12$. This pump was designed for, and obtains, high volumetric efficiency at high pressure. Maximum overall efficiency is 87 per cent.

Fig. 1 will assist in selecting reasonable values of

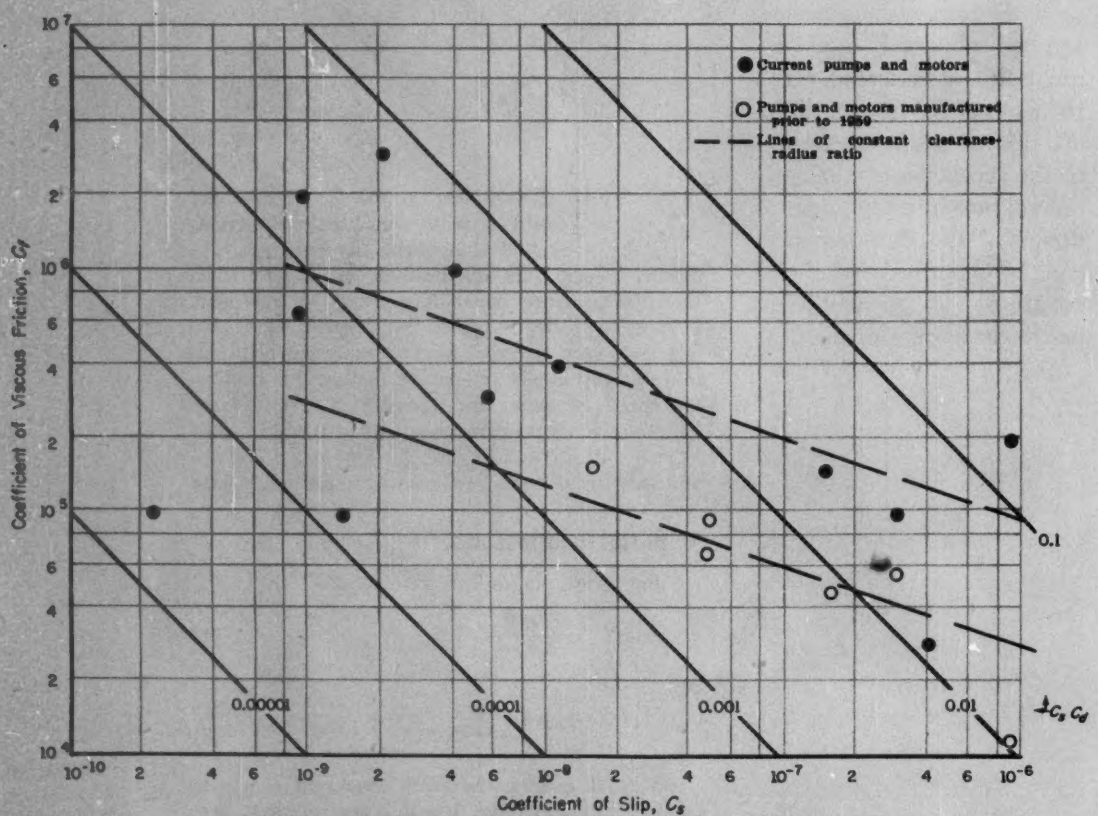


Fig. 1—Experimentally determined performance characteristics of pumps and motors.

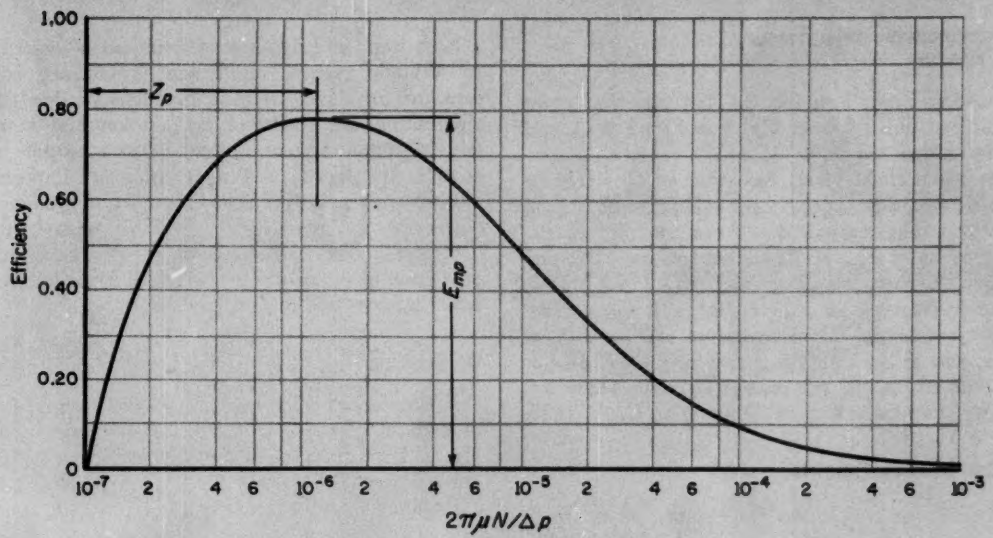


Fig. 2—Pump efficiency as a function of ratio $2\pi\omega N/\Delta p$.

C_s and C_d in relation to the present state of the art. For example, a pump with $C_s = 10^{-9}$ and $C_d = 10^4$ is clearly beyond the capabilities of ordinary manufacturing methods.

● Use of Performance Data

If complete performance data are available for a pump or motor, C_s, C_d, and C_f can be found by a simple analysis of the data. C_s can be found by plotting the slip as a function of $\Delta P/\mu$ and computing the slope of the resulting line. C_f can be found by plotting torque as a function of ΔP at constant speed and determining the slope of the resulting line. C_d is equal to the slope of the line obtained by plotting torque against μN at constant pressure.

If complete data are not available, but sufficient are available to obtain a curve showing overall efficiency as a function of speed and pressure with a liquid of known viscosity, the performance coefficients can still be determined. Equations required are:

$$E_p = \left(1 - \frac{C_s \Delta p}{2\pi\mu N}\right) \Big/ 1 + C_d \frac{2\pi\mu N}{\Delta p} + C_f \quad (3)$$

$$E_{mp} = 1 \Big/ \left[1 + C_f + 2C_s C_d \left(1 + \sqrt{1 + \frac{1 + C_f}{C_s C_d}}\right)\right] \quad (4)$$

$$Z_p = C_s \left[1 + \sqrt{1 + \frac{1 + C_f}{C_s C_d}}\right] \quad (5)$$

$$E_m = \left[1 - \left(C_d \frac{2\pi\mu N}{\Delta p} + C_f\right)\right] \Big/ \left(1 + C_s \frac{\Delta p}{2\pi\mu N}\right) \quad (6)$$

$$E_{mm} = 1 - C_f + 2C_s C_d \left[1 - \sqrt{1 + \frac{1 - C_f}{C_s C_d}}\right] \quad (7)$$

$$Z_m = C_s \left[-1 + \sqrt{1 + \frac{1 - C_f}{C_s C_d}}\right] \quad (8)$$

Equations 3-8 are represented in Fig. 2. Pump efficiency will be zero when $2\pi\mu N/\Delta p = C_s$. Motor efficiency will be zero when $2\pi\mu N/\Delta p = (1 + C_f)/C_d$.

For the pump, C_s is the horizontal intercept at $E_p = 0$. With this value of C_s, and the values of E_{mp} and Z_p from the plotted data, Equations 4 and 5 can be used to compute C_d and C_f.

For the motor, the horizontal intercept at $E_m = 0$ is the value of $(1 + C_f)/C_d$. With this value, and the values of Z_m and E_{mm} from the plotted data, C_s, C_d and C_f can be computed from Equations 7 and 8.

Since the magnitude of Z_m is affected only slightly by C_f, it is possible to use Fig. 3 in Part 1 of this series to obtain sufficiently accurate values of C_s, C_d, and C_f without resorting to simultaneous equations.

First, the value of C_s is obtained from the horizontal

Nomenclature

C_d =	Coefficient of dry friction, nondimensional
C_f =	Coefficient of viscous friction, nondimensional
C_s =	Coefficient of slip, nondimensional
D =	Displacement, units of volume per revolution
E_m =	Efficiency of motor
E_{mm} =	Maximum efficiency of motor
E_p =	Efficiency of pump
E_{mp} =	Maximum efficiency of pump
N =	Shaft rotation, revolutions per unit time
Δp =	Pressure differential, units of force per unit area
Δp_{mp} =	Maximum pressure differential developed by pump, units of force per unit area
Q =	Flow, units of volume per unit time
Q_{po} =	Flow at zero pressure differential, units of volume per unit time
T =	Torque, units of distance times force
Z_m =	Value of the ratio, $2\pi\mu N/\Delta p$, at which the maximum over-all motor efficiency occurs
Z_p =	Value of the ratio, $2\pi\mu N/\Delta p$, at which the maximum over-all pump efficiency occurs
μ =	Dynamic viscosity, units of mass divided by length and time

intercept at $E_p = 0$ in Fig. 2. The value of C_d can be obtained directly from Fig. 3 in Part 1 if C_s and Z_m are known.

This same chart yields the value of C_f since the point representing C_d and C_s is related to E_{mp}.

For example, assume that from the plot of the measured data: $E_{mp} = 79$ per cent, $C_s = 10^{-7}$, and $Z_m = 10^{-6}$. From Fig. 3 of Part 1, $C_d = 1.2 \times 10^5$.

The intersection of $Z_m = 10^{-6}$ and $C_s = 10^{-7}$ corresponds to the following values of E_{mp}: $E_{mp} = 73$ per cent at $C_f = 0.1$, $E_{mp} = 77$ per cent at $C_f = 0.05$, and $E_{mp} = 81$ per cent at $C_f = 0$. Therefore, by interpolation, at $E_{mp} = 79$ per cent, $C_f = 0.025$.

● Use of Coefficients

Whether the coefficients are assumed on the basis of the state of the art and desired maximum performance characteristics, or are obtained from experimental data, they are used in the same way to predict performance.

Basically, Equations 1 and 2 can be used to predict component performance. System design will determine the interaction of the components, which can be described by the equations of mechanics and conservation of mass.

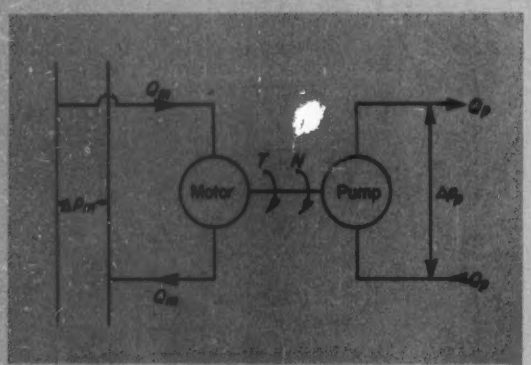


Fig. 3—Pump and motor circuit discussed in *Example*.

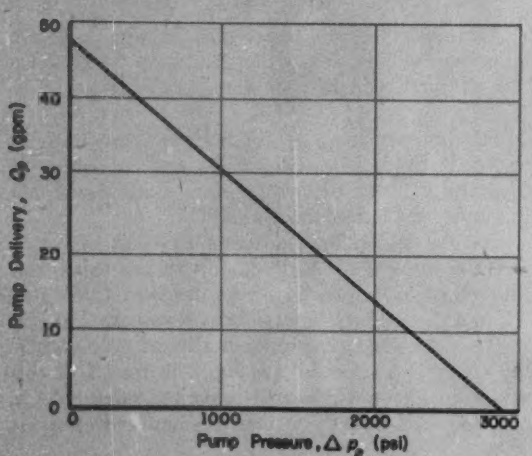


Fig. 4—Pump delivery as a function of pump pressure.

Both static and dynamic systems can be described. In a static system, input and output are either constants or slowly varying functions of time, thus eliminating the effects of acceleration and inertia. In a dynamic system, the input and output vary enough that inertia and acceleration are important.

Frequently, preliminary design of a system requires only moderate accuracy. Thus, assumed values of the coefficients will give an adequate qualitative prediction of performance. Trends and general characteristics can be predicted readily.

● Example

A pump is driven by a hydraulic motor which, in turn, is supplied by a constant-pressure system, Fig. 3. The supply of fluid is ample for the needs of the equipment being driven.

Equation 1 can be rewritten as:

$$Q_p = \frac{\Delta p_m D_m \left[(1 - C_{fm}) - \dfrac{D_p \Delta p_p (1 + C_{fp})}{D_m \Delta p_m} \right]}{2\pi\mu_p \left[\left(C_{dm} \dfrac{D_m}{D_p} \dfrac{\mu_m}{\mu_p} \right) + C_{dp} \right]} - \frac{C_{sp} D_p \Delta p_p}{2\pi\mu_p} \tag{9}$$

Subscript p indicates pump parameters and subscript m indicates motor parameters.

Maximum delivery is attained if the pump pressure differential is zero. Or,

$$Q_{po} = \Delta p_m D_m (1 - C_{fm}) / 2\pi\mu_p \left[\left(C_{dm} \frac{D_m}{D_p} \frac{\mu_m}{\mu_p} \right) + C_{dp} \right] \tag{10}$$

The maximum pressure that can be developed by the pump occurs when the delivery is zero. Thus,

$$\Delta p_{mp} = \left[\Delta p_m \frac{D_m}{D_p} (1 - C_{fm}) \right] \Big/ 1 + C_{fp} + \left[C_{sp} C_{dp} \left(\frac{D_m \mu_m C_{dm}}{D_p \mu_p C_{dp}} + 1 \right) \right] \tag{11}$$

If the pump and motor were ideal, (no losses, with coefficients $C_s = C_d = C_f = 0$,) Equation 11 would reduce to

$$\Delta p_{mp} = \Delta p_m \frac{D_m}{D_p} \tag{12}$$

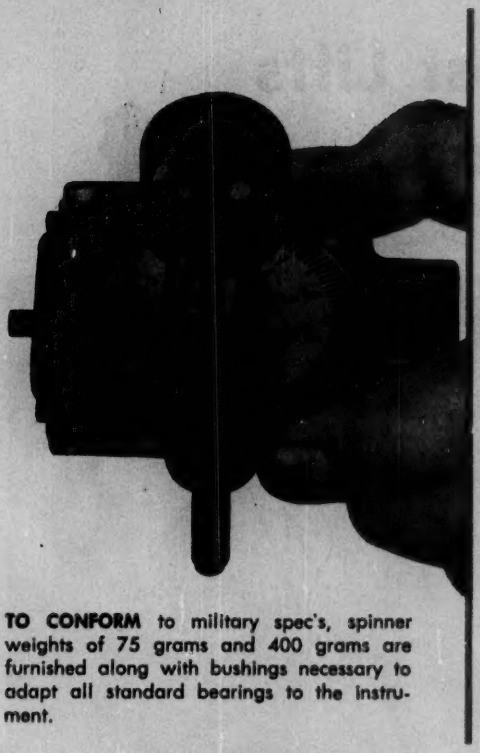
Values obtained from Equation 9 can be used to plot the delivery-pressure characteristic of a pump-motor unit. The coefficient values can be either assumed or experimentally determined. The delivery-pressure curve shown in Fig. 4 is based on the values $C_{fm} = C_{fp} = 0.03$, $C_{dm} = C_{dp} = 10^5$, $C_{sp} = 10^{-7}$, $P_m D_m / 2\pi\mu_p = 10^7$ gpm, $D_m = D_p$, $\mu_m = \mu_p$, and $\Delta P_m = 3000$ psi.

Substitution of these values into Equation 9 yields:

$$Q_p = 48.5 - 50.5 \frac{\Delta p_p}{\Delta p_m}$$

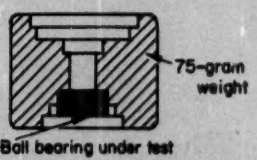
This linear relationship of Q_p to Δp_p is to be expected since Equations 1 and 2 from which it is derived are based on such a relationship. However, the prediction of this relationship is difficult, if not impossible, unless the coefficient method is used to describe performance.

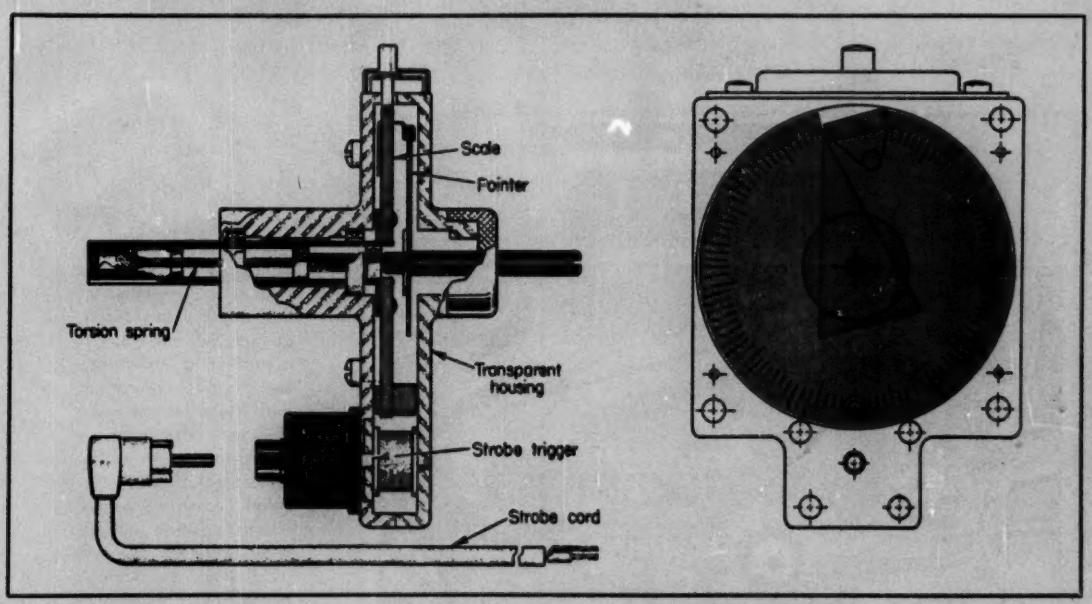
Flyweight Spinner Provides Torque for Bearing Test



TO CONFORM to military spec's, spinner weights of 75 grams and 400 grams are furnished along with bushings necessary to adapt all standard bearings to the instrument.

INTERNAL FRICTION of small bearings is quickly and accurately checked on a hand-held torquemeter. The outer race of the bearing is mounted by suitable adapters to a flyweight spinner. The inner race is mounted on the torquemeter. A spin of the weight with the fingers will usually give adequate information on the condition of the bearing. Dirt will cause noticeable deflections of the sensitive needle as the spinner slows down to about 20 rpm. Full scale readings of 1, 2, or 5 gm-cm are available. Most instrument bearings have a resisting torque of between 1 and 2 gm-cm. The tiny torquemeter is built by Power Instruments Inc., Skokie, Ill.



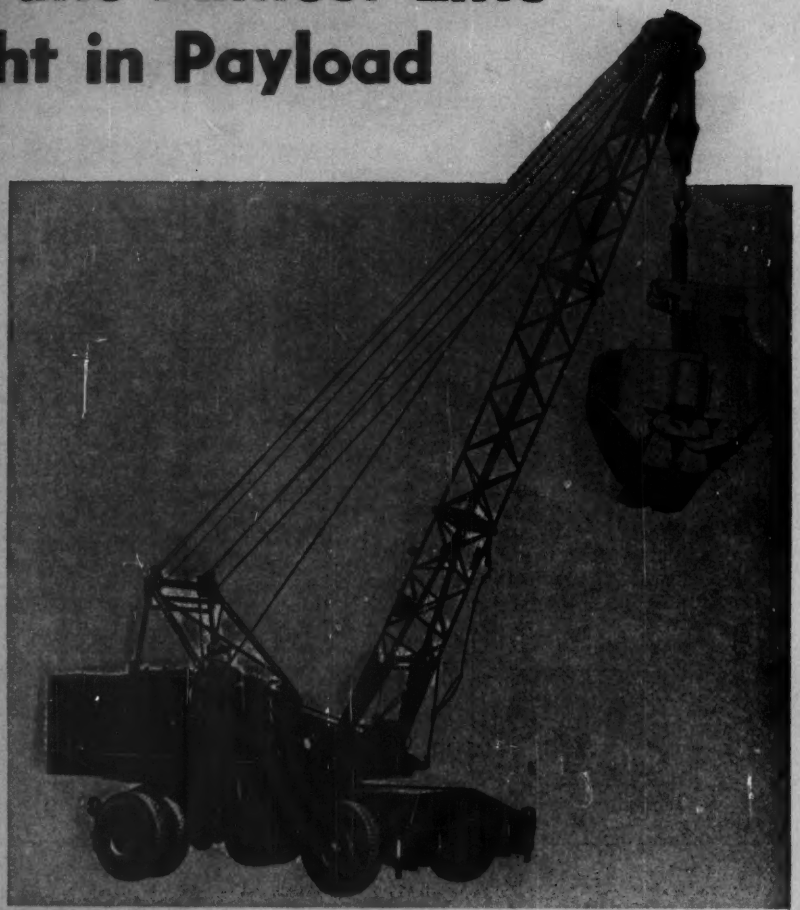


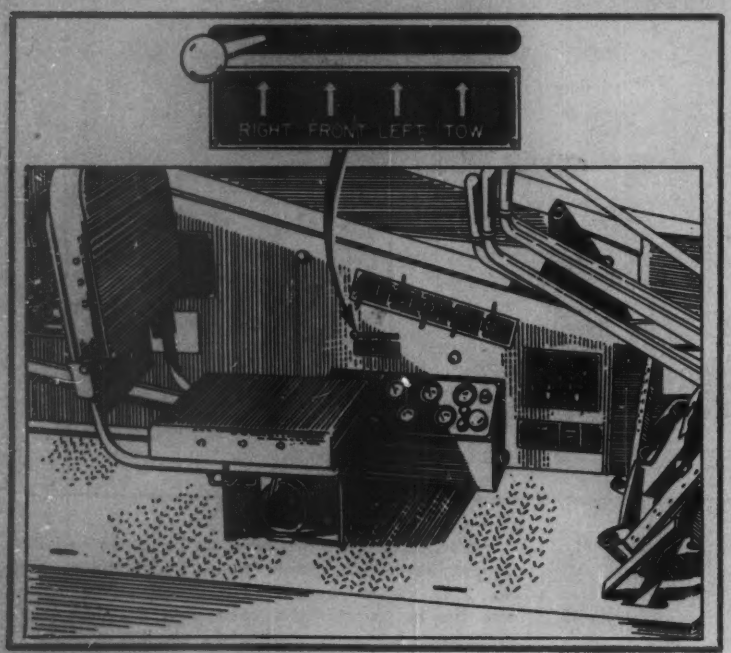
TORSION SPRING connecting shaft No. 1 and shaft No. 2 furnishes a measure of the reaction torque necessary to scale the bearing's output torque. During finger-spin test, shaft No. 2 is locked and shaft No. 1 deflects until spring torque matches the bearing output torque.

Prolonged power-driven tests can be run by mounting the bearing on the torque meter and coupling shaft No. 2 of the torquemeter to a power source. In this case the torquemeter dial spins with the shaft, so a stroboscopic trigger is provided for reading it.

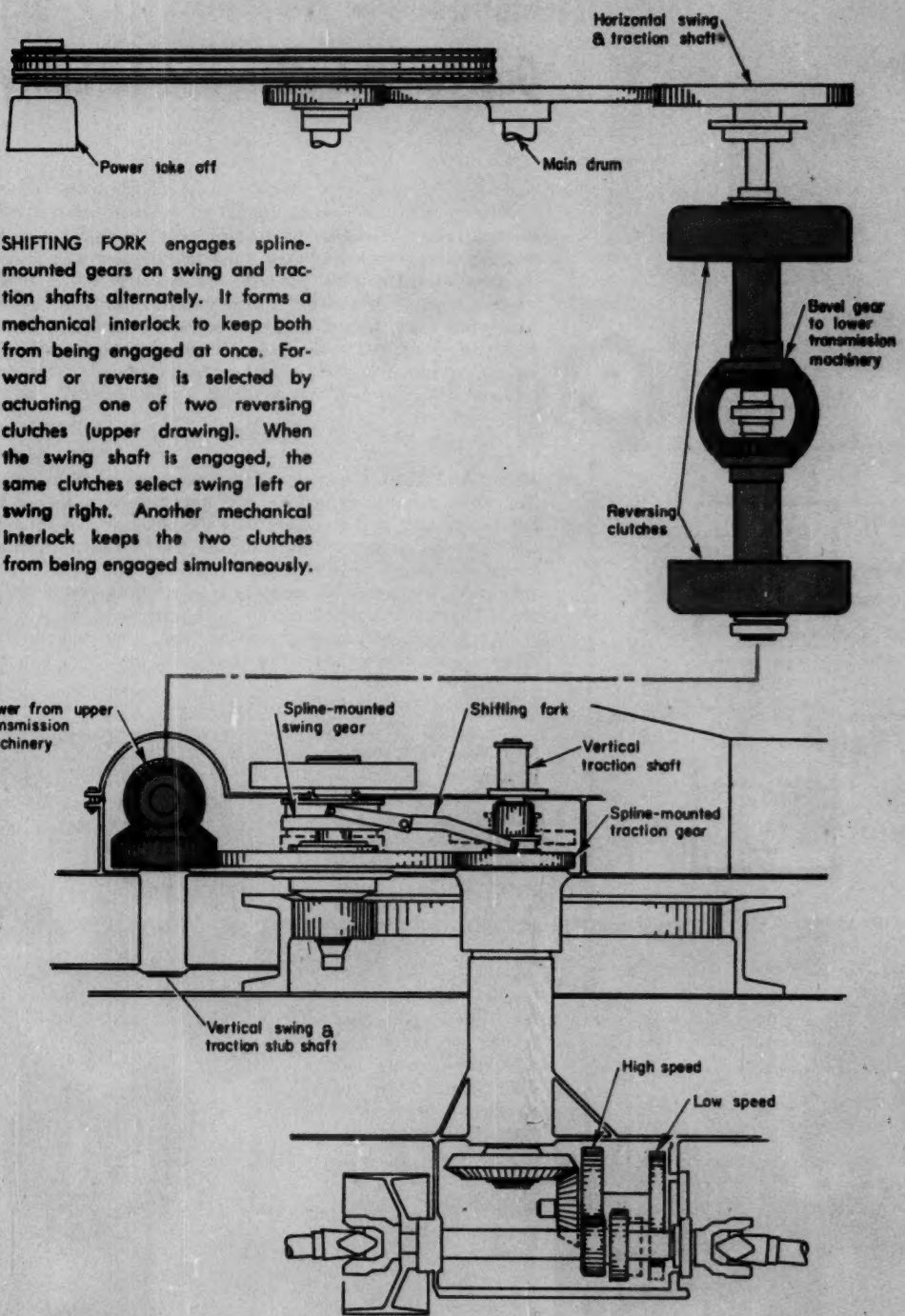
Flying Crane Almost Lifts Its Weight in Payload

WITHOUT COUNTERWEIGHTS, a new 8-ton Army crane can hold a 7-ton load at 10-ft arm length. Designers were after high lift capability in a light crane with low profile that could be stowed in a transport plane. The result was the 155 airborne crane. The air-transportable machine has been successfully operated after parachute drops. It can be rigged as a power shovel, clamshell, dragline excavator, or loading crane. Hydraulic steering system can be adjusted for over-the-highway towing at speeds up to 35 mph. It's built for the Army by Koehring Co., Milwaukee, Wis.

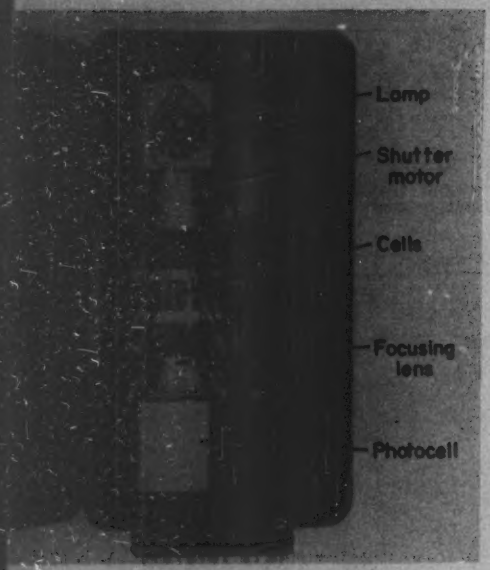




INSTEAD of the conventional steering wheel, a stick lever, mounted at the driver's left hand, guides the vehicle. It operates a multi-position valve controlling the hydraulic steering cylinder. The lever is spring-loaded to return to straight forward position when released. Fourth position on the lever, labeled "tow," is used when the crane is being towed by another vehicle. A relief valve, set to operate at 450 psi, damps out road shocks, but lets the crane follow the towing vehicle.

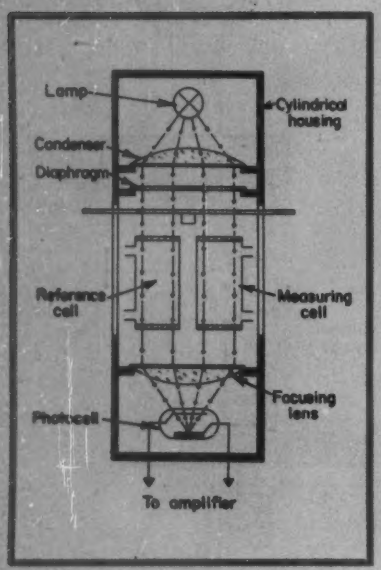


SHIFTING FORK engages spline-mounted gears on swing and traction shafts alternately. It forms a mechanical interlock to keep both from being engaged at once. Forward or reverse is selected by actuating one of two reversing clutches (upper drawing). When the swing shaft is engaged, the same clutches select swing left or swing right. Another mechanical interlock keeps the two clutches from being engaged simultaneously.

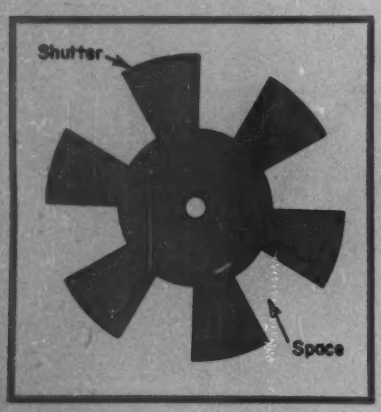


Light Beam Measures Gas Concentration and Turbidity

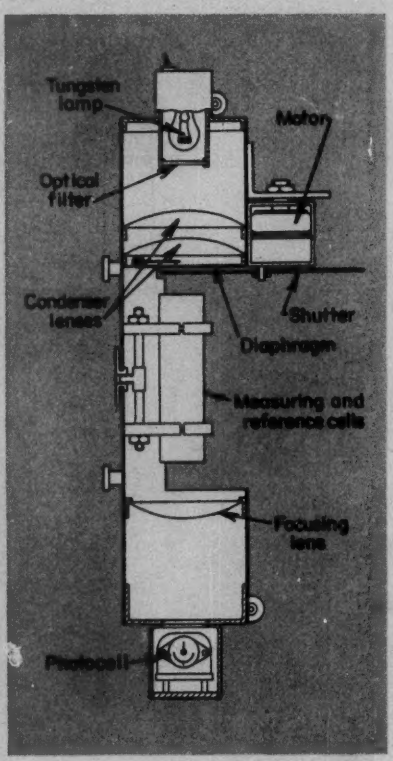
PHOTOELECTRIC gas analyzer takes advantage of the fact that gases alter the spectrum of light passing through them by absorbing some frequencies. It compares absorption of the gas to be analyzed with that of a reference gas whose absorptivity is known. A filter transmits light only in the spectrum band where absorptivity of the gas in question is particularly high. Readout with photoelectric cell is nearly instantaneous. Fluctuations in the readout indicate turbulence in the gas mixture being analyzed. The instrument is produced by George C K Withof GmbH, Kassel, Germany.



IDENTICAL PARALLEL beams of light, produced by a condenser and a diaphragm with two holes in it, pass through two cells—one filled with a reference gas, and the other with the unknown. A rotating shutter alternates the passage of light through the two cells. A focusing lens directs the beams to a photocell. As long as the cells react in the same way, the photocell produces a direct current with little fluctuation. Difference in light absorption of the two cells causes a fluctuation in the photocell output which can be read, after appropriate amplification, as a concentration of the questioned gas in the measuring cell.

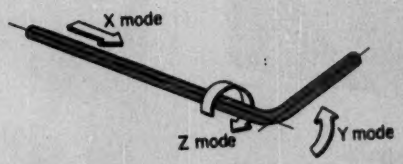


MOTOR-DRIVEN shutter is mounted in such a way that total light passing in the two beams is nearly constant, thus causing no fluctuation in photocell output as a result of shutter motion. Shutter segments and spaces are the same size and shape. Position of shutter center is determined by center distance between the two light beams, and the number of segments in the rotary shutter.

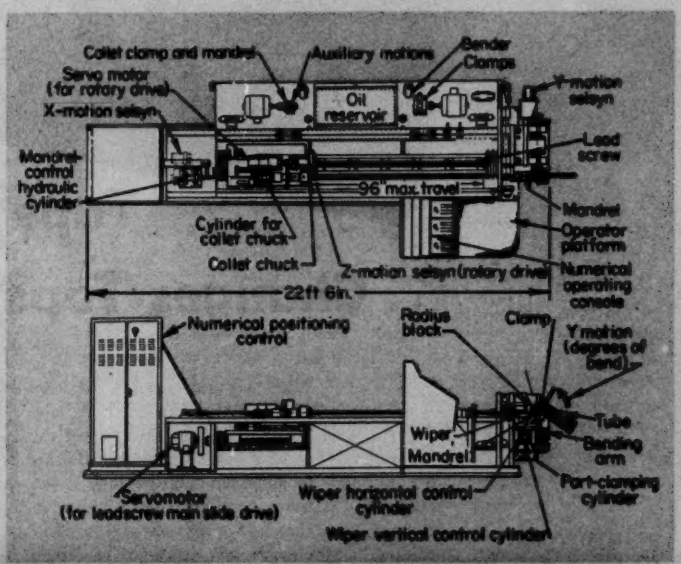


Tape-Controlled Tube Bender Forms Prototype As Tape Is Made

SELSYN-CONTROLLED hydraulic bender produces bends in hard steel tubes that are repeatable within 0.1 degree. A rotary hydraulic motor furnishes power for the bends, and a dc controlled selsyn stops it at programmed position. Simplicity of design is maintained by starting all bends in the same direction. Each bend cycle, except the first, calls for three motions: Forward linear motion, rotation, and the bending motion. Data for these three motions are tabulated on the three banks of a GE-built control console. Each bend is made on a prototype before the information is punched on tape. The bender was developed for Nu-Era Corp., Rochester, Mich.



MOTION in each of three modes is selsyn-controlled for precision and reliability. Rather than depend on flow-dividing valves, the designer and builder, Walter P. Hill Inc., provided a separate hydraulic pump for each function. By doubling up pumps that would not be operating simultaneously, he was able to use motors for each pair rated at only slightly more than the horsepower demands of the largest pump in the pair.



RADIUS BLOCKS are installed to match the tube specified for a given job. Hydraulic piston in lower center operates a clamp that is adjustable for tube diameter. All units on the bending arm (front board) swing up together about the radius block when a bend is being made.

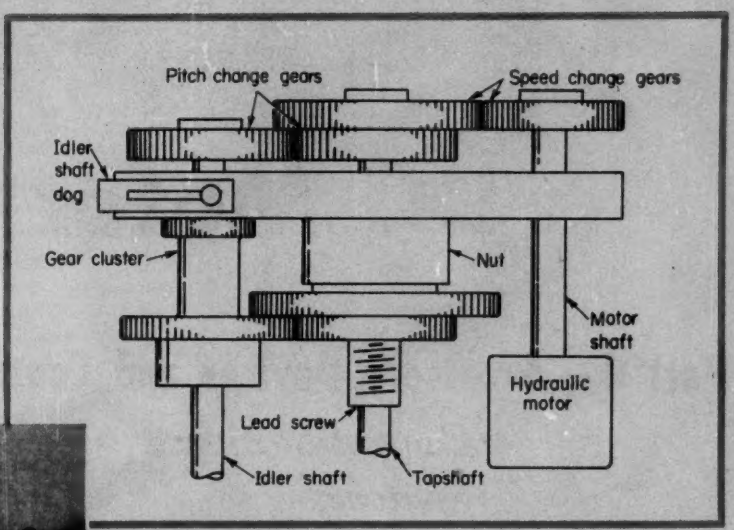
Tape Player Changes Tapes Automatically

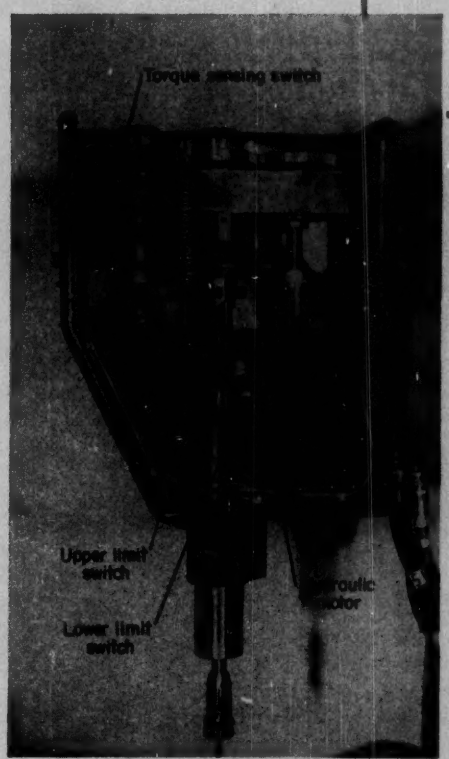
TAPE RECORDER switches tape spools automatically in much the same way a record player changes records. A tape spool from a magazine is fed into the machine; leader from the takeup spool catches the end of the tape and threads it through the playing head; tug on the finished tape reverses the mechanism for rewind; the leader disconnects; and the tape is returned to its storage compartment. Components of the system are compatible with present tape players, and the tapes may be interchanged, or present players can be made into changers with a simple kit. The tape changer was developed at Armour Research Foundation, Chicago, by Marvin Camras, senior engineer.

LEADERS are permanently fastened to the spools. Newly positioned tape rotates gently clockwise until a hook on the leader from the takeup spool catches the pin in the end of the tape. Tug of the tape reverses the mechanism to start the playing cycle. At the end of the cycle another tug reverses the mechanism again for rewind. The leader is disconnected automatically and the spool returns to its compartment in the magazine.

Differential Rotation Produces Many Pitches from One Lead Screw

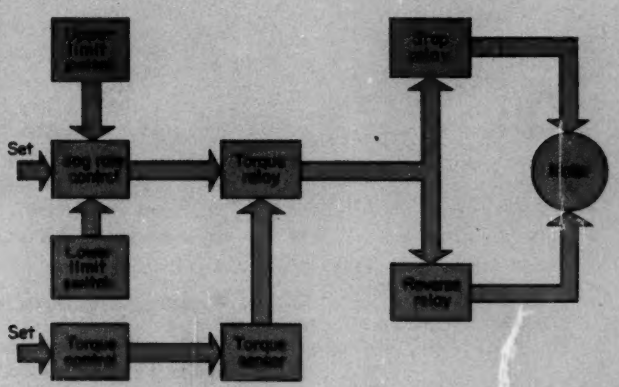
CHANGE in pitch produced by the lead screw of a new tapping machine is made by gearing the nut to rotate with the screw at a differential rate. Hydraulic torque sensor in the machine protects taps from failure due to excessive chip load. When torque exceeds a preset level, the head backs off, letting chips clear, and then re-enters the work automatically. A jog circuit in reverse does the job after the torque sensor triggers the cycle.

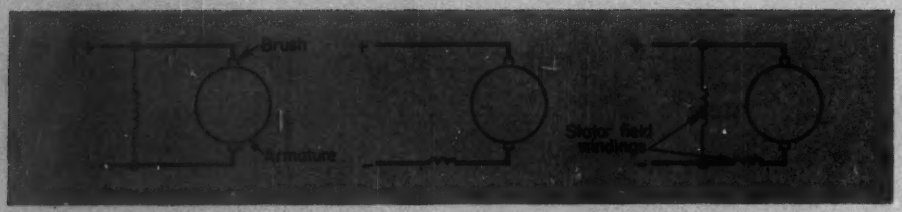




CHANGE GEARS, quickly replaced at the tops of the shafts, determine quill speed and pitch. Added range is obtained by choosing up or down position for the gear cluster. Gears are provided for standard pitches from 12 to 32. To use the basic lead-screw pitch (12), the change gear is removed from the top of the idler shaft. Cluster is placed in up position and the idler shaft is locked by turning the idler-shaft dog. Cluster is locked in position by a set screw.

TORQUE SENSOR holds applied torque to safe limits. Chief cause of excess torque is chip buildup in the tapped grooves. When set torque limit is reached, torque relay stops and reverses the motor, backing the tool out of the hole. Jog circuit switches the motor back to forward, and the tool re-enters the hole to continue cutting. Amount of back-off can be adjusted by setting the jog rate control. Multi-Pitch Hydra-Tapper was developed by Milman Engineering Co. Inc., Los Angeles, Calif.





DC Motor Control

Part 4—Accessory Devices and Controller Construction

- *Control Stations*
- *Switches*
- *Resistors*
- *Brakes*
- *Mounting Methods*
- *Enclosures*
- *Panels*
- *Component Layout*

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The Clark Controller Co.
Cleveland, Ohio

ALTHOUGH controller accessory devices operate in conjunction with the motor controller, they are usually located separately from it. Their main purpose is to originate a pilot-circuit signal which initiates controller action. Some of the commonly used devices and their functions are outlined here. In addition, the structural features of the controller itself—sizes, shapes, and arrangements—are discussed in this article.

● Accessory Devices

These devices can be operated manually or be actuated by some motion or position of the machine

Circle 18-5 on Page 19 for extra copy.

being driven by the motor. Essentially, accessory devices are the "operational brains" of a control system. They are usually located for operator convenience and many times are found on or near the driven machine. However, occasionally some types are mounted either on the controller itself or on its enclosure. For example, a pushbutton unit, Fig. 1, can be mounted almost anywhere.

Control Stations: It is common practice, when an installation requires a multiplicity of accessory control and pilot devices such as pushbuttons, meters, and rheostats, to place all such devices together on a unit assembly and make the appropriate interwiring. This unit provides a central and compact grouping of such devices, logically arranged and within easy reach of the operator. Such an assembly is called a control station.

Some control stations, Fig. 2, can be mounted directly on a machine. Control stations can also be wall-mounted or floor-mounted, Fig. 3. A common

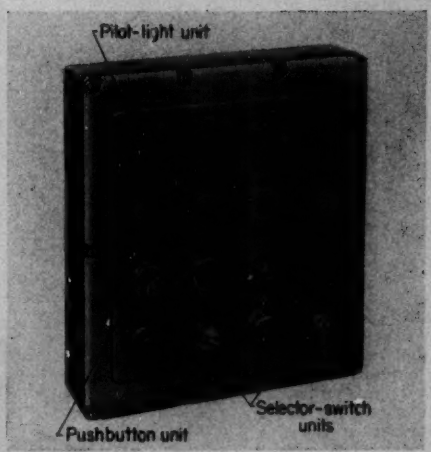


Fig. 2—Pushbutton control station for surface mounting. Units are base mounted so that the cover can be removed without disturbing the wiring and terminal connections.

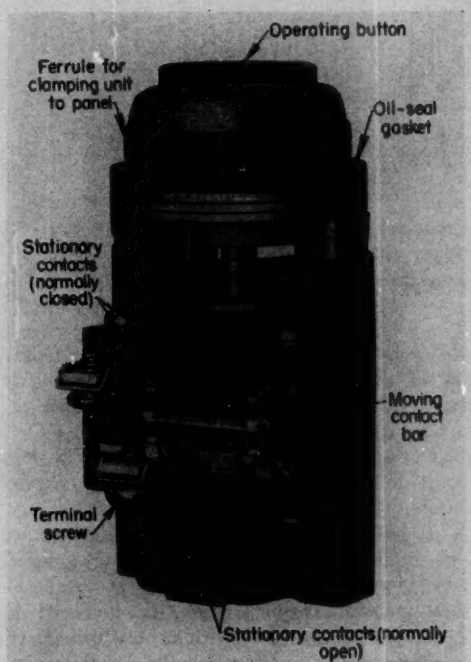


Fig. 1—Heavy-duty, oiltight pushbutton unit for panel mounting. Phantom view with button partially depressed shows internal construction.

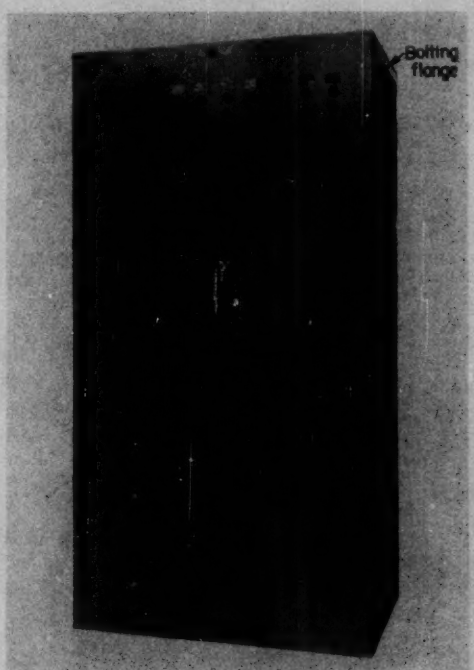


Fig. 3—One section of a floor-mounted control station. Below the rows of pushbutton and pilot-light units is a row of four master switches with pistol-grip operating handles. Other sections can be attached to the bolting flange at installation. Access doors are located at the rear of the section.

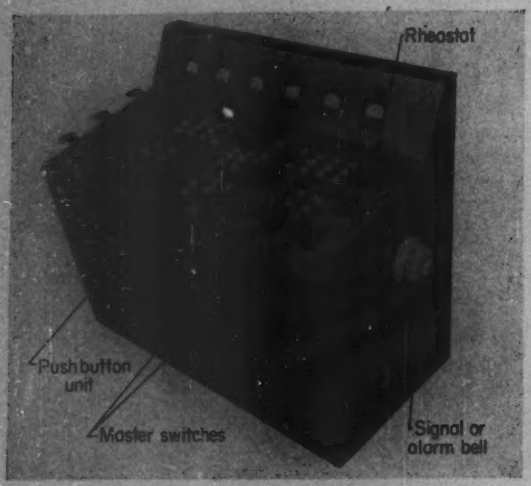
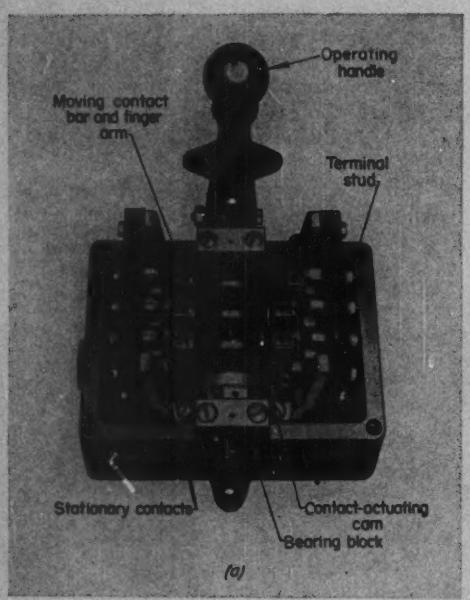


Fig. 4—Control desk with operating devices mounted on sloping top. Instruments are located in pinnacle section for best readability. Front panel slopes in at bottom to provide toe room. Removable plates on all sides permit access to wiring.

variation of the floor-mounted station is the control desk in which the devices are mounted on an inclined surface, Fig. 4.

Master Switches: Two types of master switches used extensively with dc controllers are shown in Fig. 5. Both are cam operated and are rugged and versatile devices which can be modified to meet a variety of requirements. Usually, the desired variation is easily accomplished.

These types of switches are usually available with from one to six positions in either or both directions of "throw" from the center position. They may have either maintained-contact operation or spring-return-to-center operation and are usually available in different frame sizes. The opening and closing of each circuit is independent of all others as the master-switch handle is moved. Therefore, almost an infinite variety of open and/or closed contacts can be readily obtained. A diagram showing the open



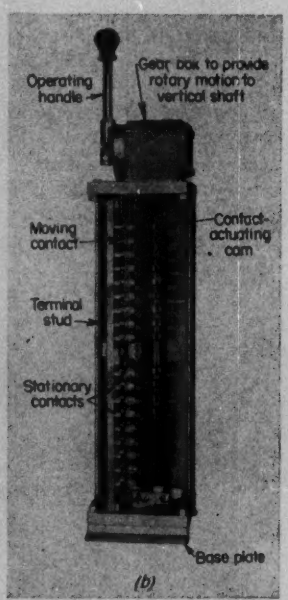


Fig. 5—Mill-duty cam-operated master switches with covers removed. Surface mounted switch, *a*, is six-circuit size. Vertical switch with base plate for floor mounting, *b*, is eighteen-circuit size. It can be mounted in control desk with only the operating handle and gear box protruding above the desk surface.

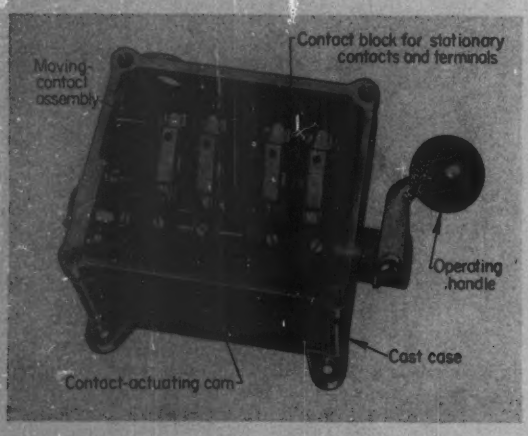


Fig. 6—Compact type of master switch limited to four circuits but suitable for heavy duty applications.

or closed condition of the circuits in relation to the position in movement of the operating handle is usually called the "development" or "contact sequence" of a master switch.

A "junior size" master switch, Fig. 6, also is often used with dc controllers. It is mechanically rugged and suitable for rough-service applications. However, because it has a maximum of four circuits, its use must be limited to applications requiring a small number of electrical contacts.

A foot-operated master switch, or foot switch, Fig. 7, is occasionally used with dc controllers. Its most common dc application is with a simple controller which is operated frequently in a repeating cycle type of application. The foot switch is usually limited to two, or possibly four, contacts.

Limit Switches: The hatchway type of limit switch.

Fig. 7—Foot-operated master switch, two-circuit size. Contacts and cams are similar to those used in compact switch of Fig. 6.

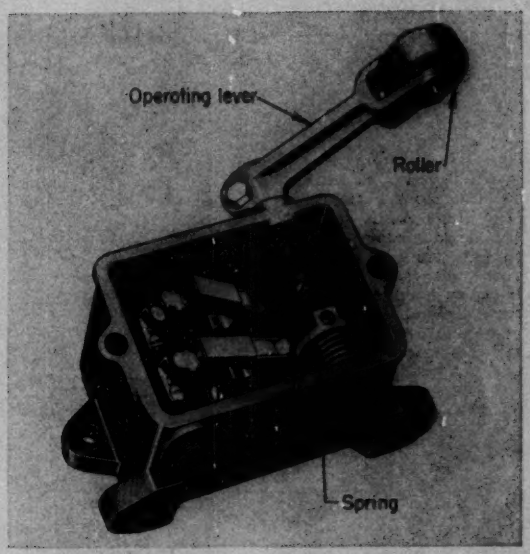


Fig. 8—Hatchway type of limit switch. Operation of the lever actuates the contacts. A spring returns the switch to its normal position.

Fig. 8, is widely used as a general-purpose limit switch. It has a spring-return and is usually available with two or four contacts.

The track-type limit switch, Fig. 9, is a maintained-contact device but in other respects is similar to the hatchway type. The track type is applied where a maintained contact is required or can be best applied.

The rotating-cam limit switch, Fig. 10, is often applied when rotating machines are being driven or where a rotary motion of the limit switch is possible. The switch contacts are operated by rotating cams. The cams are usually a split type that can be extended or shortened by an easy adjustment. Thus, a wide range of continuous adjustment is available for determining the opening and closing of the associated contact. This type of limit switch is usually available in different frame sizes so that the required number of electrical-circuit contacts can be obtained.

In some applications a rotating limit switch which can be adjusted while it is in motion, and also adjusted from outside the enclosing case, is a decided advantage. The limit switch in Fig. 11 can be considered a special adaptation of the rotating-cam type and can be of value in certain types of automated processes.

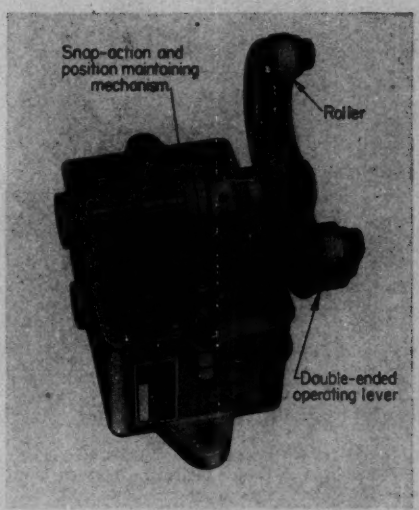


Fig. 9—Track-type limit switch. Switch is a maintained-contact device which remains in the last position to which it is actuated.

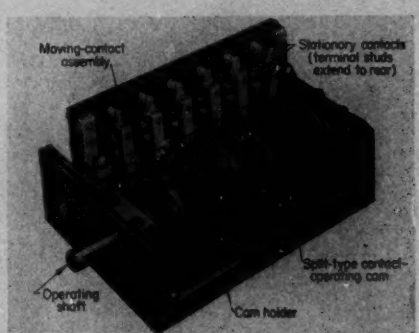


Fig. 10—Rotating-cam limit switch. Split, "butterfly" cams permit easy adjustment of contact opening and can be moved to any angular position to shift the operating range.

Resistors: A broad classification of resistors is the power-type, which are intended to be capable of carrying large or appreciable currents, and the control-type, which are intended to carry only small values of current, usually less than 1 amp. There is no definite current value at which the two are formally separated. This discussion pertains primarily to power-type resistors.

Resistors are made of many different types of materials. Generally, the resistor material is an alloy with nickel, chromium, copper, or iron as the princi-

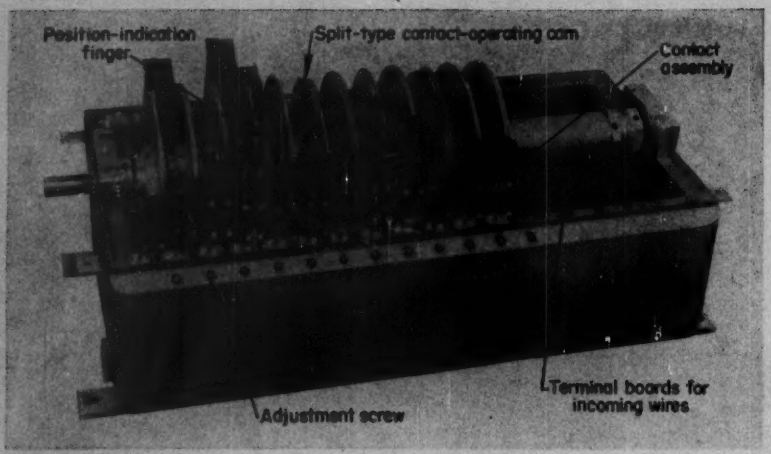


Fig. 11—Rotating-cam limit switch designed to permit adjustment from outside of the case while switch is rotating. The cover contains a window on each side with scale graduations for each circuit. The finger on each contact assembly moves behind the window calibration to indicate the amount of adjustment.

Fig. 12—Edgewound resistor assembly. End terminals are welded to ribbon of each unit. Units are connected in series or parallel by flat copper straps. Connections between frames are made by formed copper connectors.

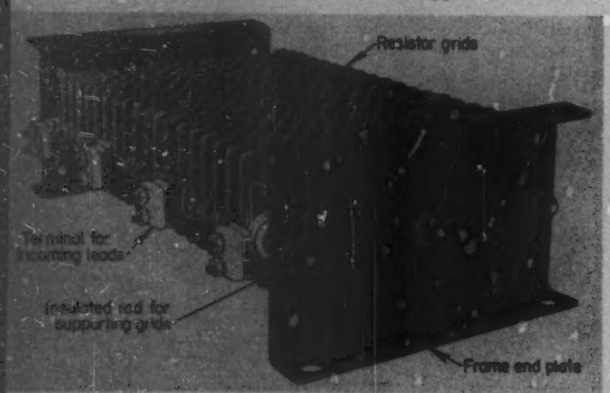


Fig. 13—Cast-grid resistor assembly which is commonly called a "box." Boxes can be bolted together and interconnected as required. They can be mounted in a supporting frame that permits easy removal of individual boxes.

pal constituent. The resistance value of the alloy used should not change appreciably as temperature changes. In use, resistors reach a high temperature because of the power consumed. It is conventional practice to allow resistors to operate at a maximum temperature rise above ambient of 250 to 375 deg C.

The edgewound resistor, Fig. 12, is made of flat-ribbon material wound on edge and supported by a core of insulating material. This construction results in a rugged and shock-resistant assembly, and the edgewound resistor is often referred to as being non-breakable.

The cast-grid type of resistor, Fig. 13, as its name implies, uses a cast construction for each resistor element. The resistor material is an alloy of steel or iron. This type of unit is fragile and should not be used in locations subject to great shock or vibration. However, the cast-grid resistor is able to absorb and withstand high overloads for a short period of time and, therefore, has many control applications.

The ventwound resistor, Fig. 14, is a wire-wound type. It is made of round wire wound on a ventilated insulating core. The general construction is similar to that for the edgewound type, but its appearance is somewhat different because of the shape of the resistor material and the shape of the support core. This type is usually used for lower current-rating applications and has a correspondingly higher resistance rating than the higher-current edgewound type.

Another type of resistor unit, the punched grid, is somewhat similar to the cast type but is punched from flat-stock material. The punched-resistor unit is much less fragile than the cast-grid resistor. In recent years, the punched-grid resistor has become increasingly popular.

Rheostats: These devices are basically designed to be used in the shunt-field circuits of motors or generators. When used with a motor, the rheostat provides a means for adjusting the speed. When used with a generator, the rheostat provides a means for adjusting the output voltage. Basically, a rheostat can be defined as an easily adjusted resistor.

Rheostats are usually manually operated. How-

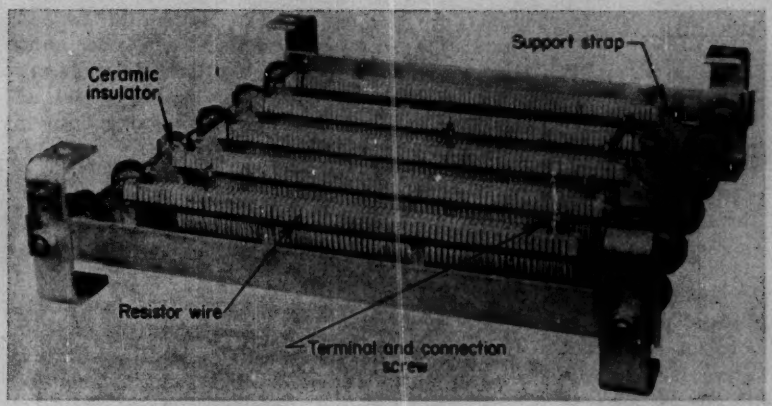


Fig. 14—Ventwound resistor assembly. Round-wire resistor material is wound on an insulating core which is ventilated to provide better cooling.

ever, they can be driven by a pilot-type motor or even by chain or gears from some mechanical actuating source.

A heavy-duty field rheostat is shown in Fig. 15. Its resistor elements are individual grid-type units individually mounted on the supporting insulating material.

The field rheostat in Fig. 16 is a plate type. If a fault occurs in some portion of the resistor material, it is not practical to repair or replace the damaged portion. This type is made in different plate-diameter sizes. Two or more plates can be operated in tandem from one shaft and handle as a relatively compact unit. Plate rheostats are versatile as well as relatively economical and find wide use.

Brakes: Various types of brakes are often necessary in dc motor control. For example, mounting a brake on the nondrive end of a double-shaft motor is a common procedure. Also, brakes are widely used in conjunction with dc controllers to aid in stopping a machine or as a holding device to prevent a machine from moving when the driving motor is not energized.

Brakes which are mechanically or hydraulically operated have no direct operational connection with the controller. The magnetically operated brake, Fig. 17, receives its operating signal from the controller.

● Controller Construction

The physical complete entity of a magnetic controller is made up of a number of contactors, relays, and other devices. The protection, support, and layout of these components and the electrical wiring are provided by the controller structure. The shape of the over-all structure is determined by the proposed mounting or location of the controller.

Mounting Methods: Controllers can be built for wall or floor mounting. In addition, they can be constructed in special sizes and shapes which can be built in or mounted on some particular machine. Controllers can also have open construction or they

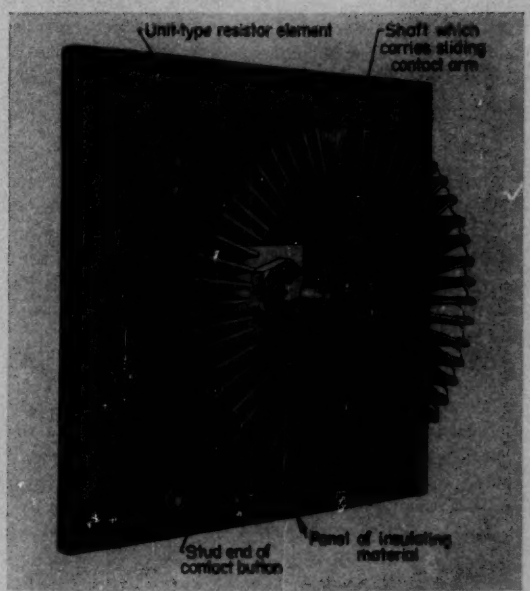

Unit-type resistor element
Shaft which carries sliding contact arm
Stud end of contact button
Panel of insulating material

Fig. 15—Rear view of unit-resistor type of field rheostat. Any resistor element that is damaged can easily be replaced. Contact buttons and sliding arm are on front of rheostat.

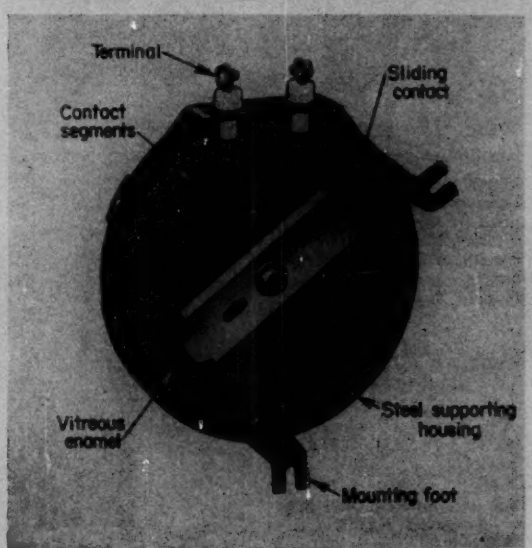


Fig. 16—Rear view of plate-type field rheostat. The resistor material is embedded in vitreous enamel.

can be enclosed in a cabinet.

The use of wall-mounted controllers is limited by the size that can be handled and installed. In addition, access for maintenance and repair may become more difficult as size increases. Therefore, it is conventional practice to limit the size of a wall-mounted controller to one having a surface area of approximately 1500 sq in.

Wall-mounted controllers are usually enclosed. However, it is sometimes possible and practical to build a wall-mounted controller of the open type.

Floor-mounted controllers have the one disadvantage of requiring an appreciable amount of floor space. Otherwise, they are easy to handle and install, including the installation wiring, and are satisfactory from a maintenance standpoint because of the accessibility of all components and wiring. Consequently, floor-mounted controllers are extensively used.

Enclosures: If a floor-mounted controller is located in a control room or in some other location reasonably well protected from dirt and mechanical damage, an open panel is satisfactory. However, in a nonprotected area, such as the floor of an industrial plant or the runway of an overhead traveling crane, the protection of an enclosure is required.

A controller enclosure has two distinct and basic functions. The most evident is that the enclosure protects the controller from dirt and other atmospheric conditions, and also from mechanical damage. Perhaps not quite so evident is the second and equally important function of protecting operating personnel from electrically live parts.

Different types of enclosure construction are necessary for different types of service conditions. Designations and descriptive definitions for various standard types of enclosures are outlined in NEMA Standards Publication IC 1-1959, Par. 2.68.

The NEMA Type 1 general-purpose enclosure is probably most generally used. A slight variation, known as the Type 1 with dust seals, is also extensively used. Type 5, dusttight, also finds considerable use when the controller must be located in an unusually dirty or dusty area. Several other types are listed in NEMA, but they are not too often used on dc controllers.

Enclosures for floor-mounted controllers are usually so built that they can be added to the controller as the final stage of assembly. Therefore, the controller can have the same construction regardless of whether it is to be the open or the enclosed type.

Panels: Dc-controller components are usually designed to be assembled on a panel or base of insulating material. Studs extend through to the rear of the panel so that all the wiring is done on the rear. In a controller, the component devices are grouped and mounted on one or more pieces of the panel base material. These panels are then mounted on, and supported by, a structural-steel framework.

If the controller is subjected to unusual vibration or shock, there is some possibility of undue breakage of panel base material. To alleviate this, it is common practice to use a type of construction often called "individual slate," but which might better be described as small-slate or small-base construction. Controller components are mounted either individually or in groups of two or possibly three on relatively small pieces of panel base material. These com-

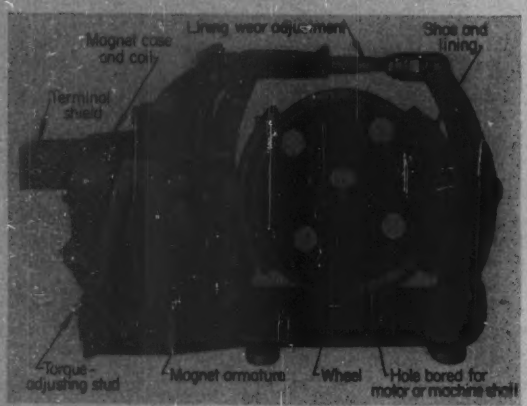


Fig. 17—Magnet-operated dc brake. Braking torque is applied by spring and released by magnet operation. There are seven NEMA brake sizes having wheel diameters ranging from 8 to 30 in.

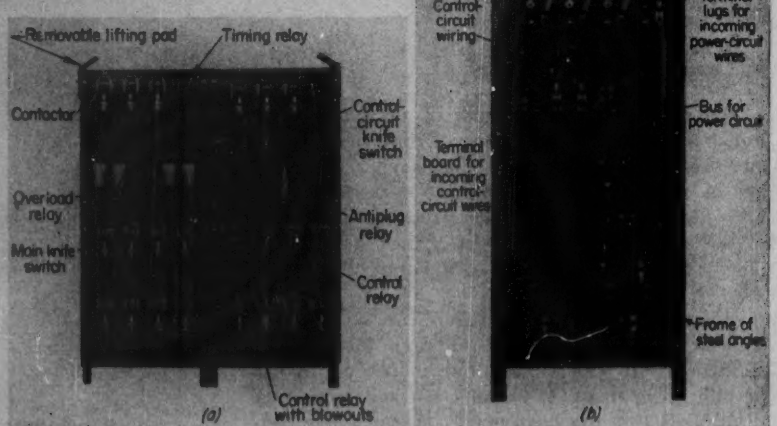


Fig. 18—Front, *a*, and rear, *b*, of typical NEMA Class D panels.

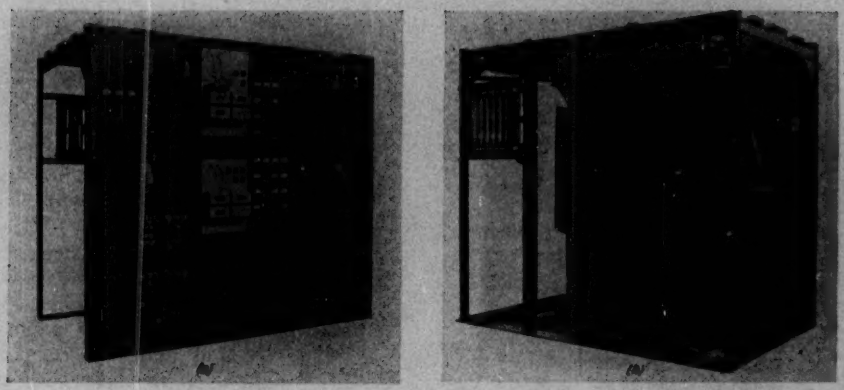


Fig. 19—Front, *a*, and rear, *b*, of a panel conforming to NEMA Class A construction.

paratively small units are then mounted on a steel frame.

Recently, devices which are front-connected, and usually "dead-back," have been developed. These devices permit steel-panel mounting and front wiring. The use of this type of construction is expected to become more widespread.

NEMA has also described and defined four different basic classes of panel construction. These are covered by NEMA Standard IC 1-1959, Par. 41.02.

Class D construction is the simplest and is conventionally considered the "standard" class for dc controllers. It is a nonself-supported structure and can most simply be described as a picture frame on legs, Fig. 18.

Class C construction is also nonself-supported, basically similar to Class D, but with additional features. These features include: 1. Addition of a floor sill, often called a "channel base." 2. Extension of the panel base material to the floor sill. 3. Grouped terminal facilities for armature and field-circuit incoming leads.

Class B construction, also nonself-supported, is essentially the same as Class C but with provision for bracing to a wall. Steel members project to the rear from the top of the panel for this purpose. The other main feature that is added is a main bus bar or cable which acts as a feeder and/or interconnecting means for the main power supply.

Class A construction is self-supporting, Fig. 19. Essentially, it is similar to the Class B structure but with the addition of vertical members at the rear of the wall brace to provide a full box frame of structural steel. In addition, power-circuit resistors are mounted in the rear portion of the frame and are supported by additional framework members, brackets, or shelves.

Class A, B, or C construction is ordinarily used on large installations such as those for processing lines. Classes A and C are most commonly used for this purpose. In fact, Class C is usually considered the basic construction for processing-line installations.

NEMA standards for panel class of construction do not include dimensional requirements. Obviously, the width of a panel must vary, depending on the size and number of devices required for the controller function. A height dimension is usually selected as a "standard" by each manufacturer. This dimension usually varies between 66 and 90 in. A manufacturer might list two, or perhaps more, alternate height standards.

The insulating panel base material upon which the controller components are mounted is usually slate or ebony asbestos wood. Slate is a natural rock product obtained by mining. Ebony asbestos wood, or "ebony asbestos," is a synthetic material containing asbestos fiber. It is produced by a heat and pressure-molding process. The differences in properties between the two materials are not extensive, and both are widely used for industrial controllers. Other materials are used to a limited extent.

Component Layout: In laying out a controller, proper electrical clearances must be maintained between adjacent devices and between devices and framework. Manually operated devices, such as knife switches, should be located where they are convenient to the operator. Visual devices, such as ammeters and voltmeters, should be located where they can be read accurately. Major devices, such as contactors, should be located relative to each other so that they operate in a reasonable pattern or sequence and permit power bussing or cable to be kept as simple as possible. Such devices as relays, which perform similar or sequential functions, should be grouped together and/or arranged in the same order in which they operate.

To provide controllers which have correct clearances and are consistent with each other, a manufacturer usually establishes certain standard and basic layout spacings and arrangements for each general type of controller. This practice reduces the effects of the human element and also ensures that all modifications of basic controllers start from the same point. A more uniform product is the result.

Next article in this series will discuss general-purpose and definite-purpose dc motor controllers and their applications.

References

This article is the fourth in a series by J. Ronald Wickey on dc motor control. Previous articles and issues of Machine Design in which they appeared are:

1. Motor Types and Characteristics ..... July 20, 1961
2. Circuit Functions of Control Devices ..... August 3, 1961
3. Basic Controller Hardware ..... August 17, 1961

FORCE WORK POWER

Why not add

ZING and SNAP

F

Fs

$F\frac{ds}{dt}$

$F\frac{d^2s}{dt^2}$

$F\frac{d^3s}{dt^3}$

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HOW fast can a system deliver mechanical energy? This question may be important—but is usually not answered in a conventional description of energy devices.

For example, a 10-hp direct-current motor may have a starting torque of 200 lb-in. But this torque and horsepower specification doesn't tell how fast the motor can make its power available. At present, the inertia of the rotor or the speed-torque curve are used as indications of the response of the motor. It would be desirable to have a simple means of describing the response of energy systems.

Two parameters are proposed: "Zing" would be a measuring of just how quickly a system could deliver its power. "Snap" would indicate the rate of zing.

Relationships between movement, velocity, acceleration, and jerk are shown in the upper part of Table 1. Jerk is quite useful in describing shock loads. In the same manner, relationships between force or torque, work, power, zing, and snap are shown in the lower half of Table 1. Average zing is defined as the average rate of expending power, or the power expended divided by the time in which the power was expended. Average snap is defined as average rate of expending zing, or the zing expended divided by the time in which zing was expended. Zing is the scalar product of force or torque and acceleration. Generally, the two vectors are collinear; therefore, the magnitude of zing is simply the product of the absolute values of the two vectors.

The concept of zing can be used in many ways. For example, when rating centrifuges, it is common to give the time for the centrifuge to come up to rated speed with maximum load. If a centrifuge is accelerated at the rate of 2 rad/sec² under a driving torque of 110 lb-ft, the centrifuge would have a zing of 220 ft-lb per sec².

At present, commercial transducers can measure torque or force and acceleration. If the output from a torque or force transducer is fed to an accelerometer, the accelerometer output will be proportional to zing. With tongue in cheek, one might call this transducer a "zinger." The electrical schematic for a strain-gage zinger is shown in Fig. 1.

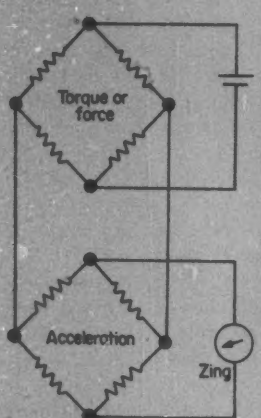

Fig. 1—The zinger, a device for measuring zing — the product of force or torque times acceleration.

Table 1—Kinetic Relationships

	Rectilinear Translation		Pure Rotation	
	Relationship	Units	Relationship	Units
Displacement	s	ft	θ	rad
Velocity	$v=\frac{ds}{dt}$	ft/sec	$\omega=\frac{d\theta}{dt}$	rad/sec
Acceleration	$a=\frac{dv}{dt}$	ft/sec²	$\alpha=\frac{d\omega}{dt}$	rad/sec²
Jerk	$j=\frac{da}{dt}$	ft/sec³	$\gamma=\frac{d\alpha}{dt}$	rad/sec³
Force or Torque	F	lb	T	lb-ft
Work	$W=Fs$	ft-lb	$W=T\theta$	ft-lb
Power	$P=Fv$	ft-lb/sec	$P=T\omega$	ft-lb/sec
ZING	$Z=Fa$	ft-lb/sec²	$Z=T\alpha$	ft-lb/sec²
SNAP	$S=Fj$	ft-lb/sec³	$S=T\gamma$	ft-lb/sec³

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19 ways of Attaching Coil Springs

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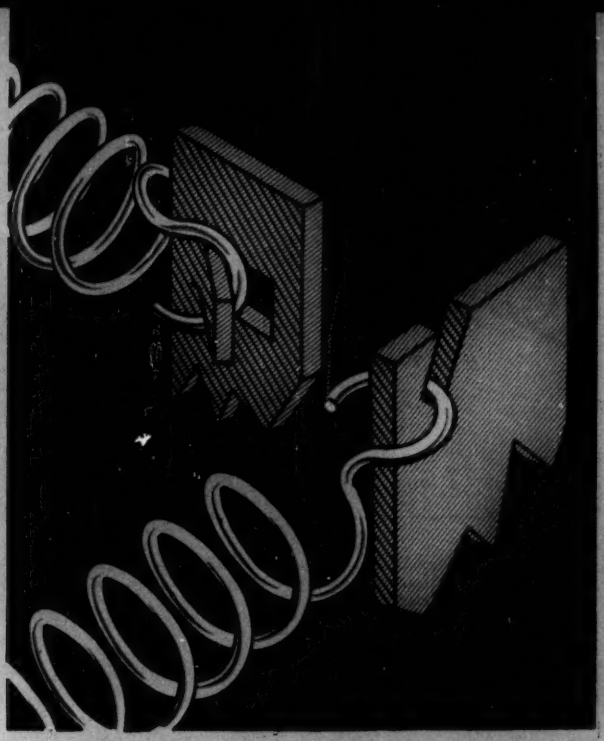
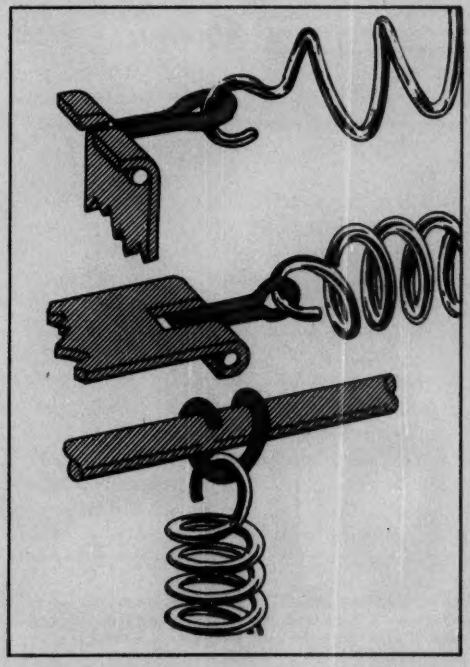
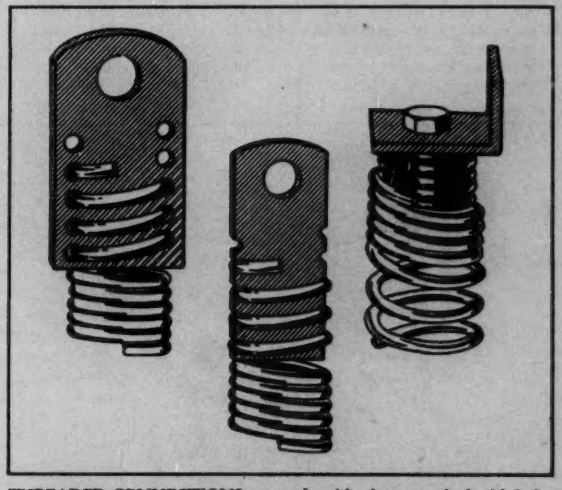


HOOKS FOR SPRING EYE are provided by tongue pierced from plate or angular slot in plate edge. Axial spring tension draws eye to bottom anchoring position.

METHOD of attaching a coil spring is influenced by: Cost of providing and attaching some kind of anchoring part, ease of attaching and removing springs in close quarters or in a complicated mechanism, and provisions for adjusting spring tension after a spring has been installed. A good rule-of-thumb for design is: Use the simplest arrangement that satisfies all requirements. Ideas presented here, although they do not cover all conditions that may be encountered, should at least provide a starting point from which modifications may be devised to fulfill this objective.





THREADED CONNECTIONS are made with plates punched with holes of proper pattern, or suitably notched to save space. Spring can be turned onto true threads if pitches match. In every case here, axial adjustments of overall length involve changes in numbers of active spring coils.

DISENGAGEABLE ANCHORS can be formed from cotter pin bent to engage edge of bracket. Deeper slot and curled lip on bracket facilitate horizontal or vertical assembly. Wire loop with opposing hooks can be slipped onto a rod and turned to engage hooks.

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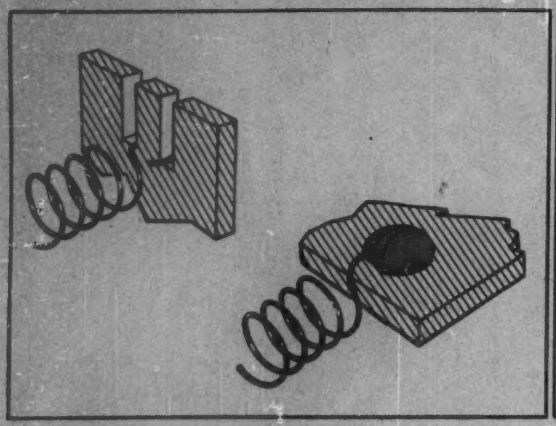
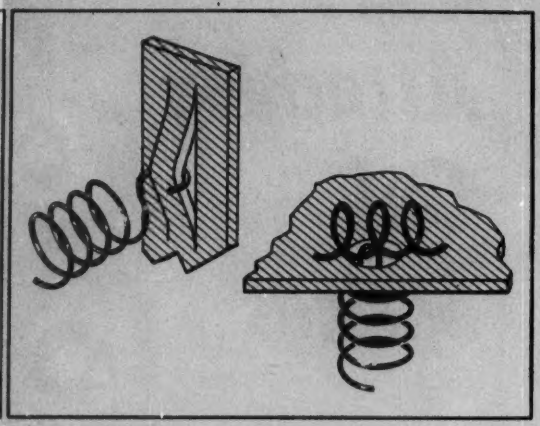
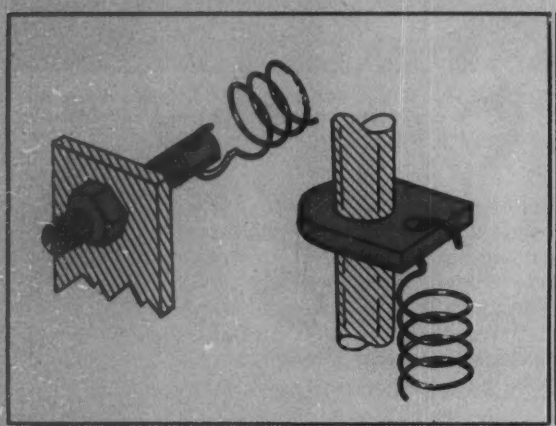


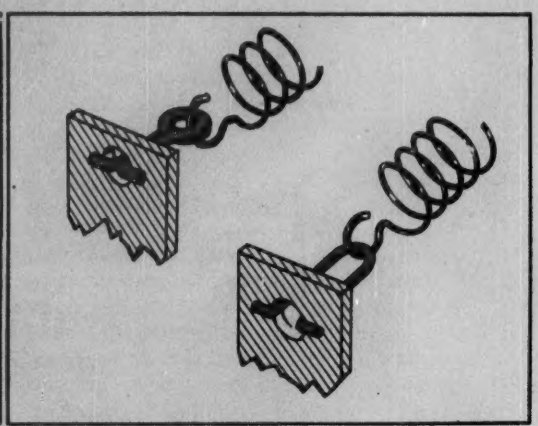
TYPES OF POSTS include integral, which is formed by saw slots in plate, and conventional rivet which is passed through eye of spring and then into hole in base member.



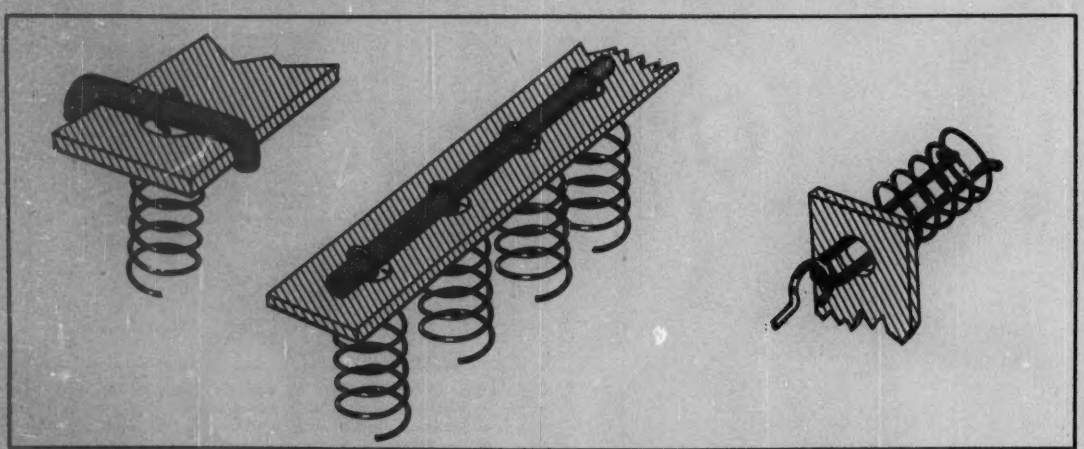
ATTACHING LOOPS include pierced lug, integral with plate, and coarse-pitch large-diameter spring which can't be pulled through slot.



AXIAL POSITIONERS change minimum-load or no-load position of spring eye. Adjustment element is threaded post or collar jammed in place on rod. Spring tension tilts collar, causing edges of hole to pinch rod. Position is adjusted by overcoming pinch moment first.



BENT-WIRE ANCHORS include cotter pin with ends bent over after insertion, and spring wire with bent ends. Spring loop can be removed by compressing until ends clear hole.



PIN RETAINERS receive spring eye through hole. Pin position can be held by bent ends. Number of springs can be one or more.

COMPRESSION ARRANGEMENT carries compression spring on long wire loop bent at ends. Loop, which forms spring core, may need to be flexible if bent ends must clear holes during assembly.

Noise Conversion Nomogram

JOSEPH I. SCHWARTZ and DONALD C. THOMSON
Noise Reduction Division
U. S. Naval Engineering Experiment Station
Annapolis, Md.

INCREASED emphasis on noise reduction by military and commercial activities has generated much data on noise and vibration. Noise data such as structural vibration measurements are not always available in the same terms. Some data are reported as displacements, some as velocity level in decibels, and as acceleration level in decibels. This nomogram provides an easy and reasonably accurate conversion from one term to any other. In addition, a normal range of values for transducer sensitivity is included so that any initial determination of velocity or acceleration is simplified. These scales also allow the calculation of corrections for transducer nonlinearity.

Units must be consistent. Therefore, if acceleration level in decibels, A_{db}, is referred to a base of 10^{-3}, cm (rms) per sec^2, then acceleration sensitivity must be given as v per cm (rms) per sec^2 or as v per g (rms). See Nomenclature.

Conversely, if accelerometer sensitivity is given as v per cm (peak) per sec^2 or as v per g (peak), then A_{db} is referred to a base of 10^{-3} cm (peak) per sec.^{2} This caution applies particularly to vibration transducers because several ways are used to calibrate them.

Noise in the conventional sense is generally referred to as airborne noise. For noise reduction, the term "vibration" or "structure-borne vibration" is generally used synonymously with noise or structure-borne noise.

Two or more variables must be known to determine any other dimension. For instance, accelerometer sensitivity and its voltage output are required to obtain acceleration. Furthermore, frequency must be known to convert acceleration to velocity.

Among the simple relationships that can be solved by the Nomogram are $A = v/S_A$, $V = v/S_V$, $D = V/\omega$, $d = 0.3937D$, $\omega = 2\pi f$, $D = A/\omega^2$, and $A = V\omega$. More complex relationships include

$$A_{db} = 20 \log_{10} \frac{A}{A_r} \qquad V_{db} = 20 \log_{10} \frac{V}{V_r}$$

$$V_{db} = A_{db} + 44 - 20 \log_{10} f$$

Example 1: Assume that a velocity-type pickup has a sensitivity (S_V) of 38×10^{-3} v (rms) per cm (rms) per sec and the output is 0.0047 v (rms) at 100 cps. Determine the velocity, acceleration, A_{db}, V_{db}, and the single-amplitude rms displacement.

SOLUTION: Draw a line from 0.0047 v through $S_V = 38 \times 10^{-3}$ to intersect the velocity or V_{db} scales. Read $V = 0.125$ cm (rms) per sec and $V_{db} = 102$. From that point draw another line through 100 cps to the acceleration or A_{db} scales. Read $A = 80$ cm (rms) per sec^2 and $A_{db} = 98$. To determine displacement, convert f at 100 cps to ω. Finally, draw a line from 102 V_{db} through ω to intersect the displacement scales at 1.95×10^{-4} cm (rms) or 7.68×10^{-5} in. (rms).

Example 2: Find the peak single-amplitude displacement which exists, when an accelerometer with an acceleration sensitivity of 63.5×10^{-6} v (rms) per cm (peak) per sec^2 has an output of 2 mv (rms) at 1000 cps.

SOLUTION: Draw a line through points corresponding to the given voltage and acceleration sensitivity to intersect 31.5 cm (peak) per sec^2 on the acceleration scale. Draw another line from 31.5 cm per sec^2 through 1000 cps on the f scale to intersect the velocity scale at 5.0×10^{-3} cm (peak) per sec. Convert cps to radians per sec. Finally, draw a line from 5.0×10^{-3} cm (peak) per sec through ω to intersect the displacement scale. Read a peak single-amplitude displacement of 7.9×10^{-7} cm or 3.1×10^{-7} in.

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2. "Specifying the Characteristics of Pickups for Shock and Vibration Measurement," ASA Z24.21, American Standards Association, New York, Jan. 24, 1957.
3. "Noise Measurements of Shipboard Machinery and Equipment," Military Standard 740 (ships), Feb. 6, 1961.
4. C. M. Harris—*Handbook of Noise Control*, McGraw-Hill Book Co. Inc., New York.
5. A. P. G. Peterson and L. L. Beranek—*Handbook of Noise Measurement and Measurement of Vibration*, General Radio Co., Cambridge, Mass.

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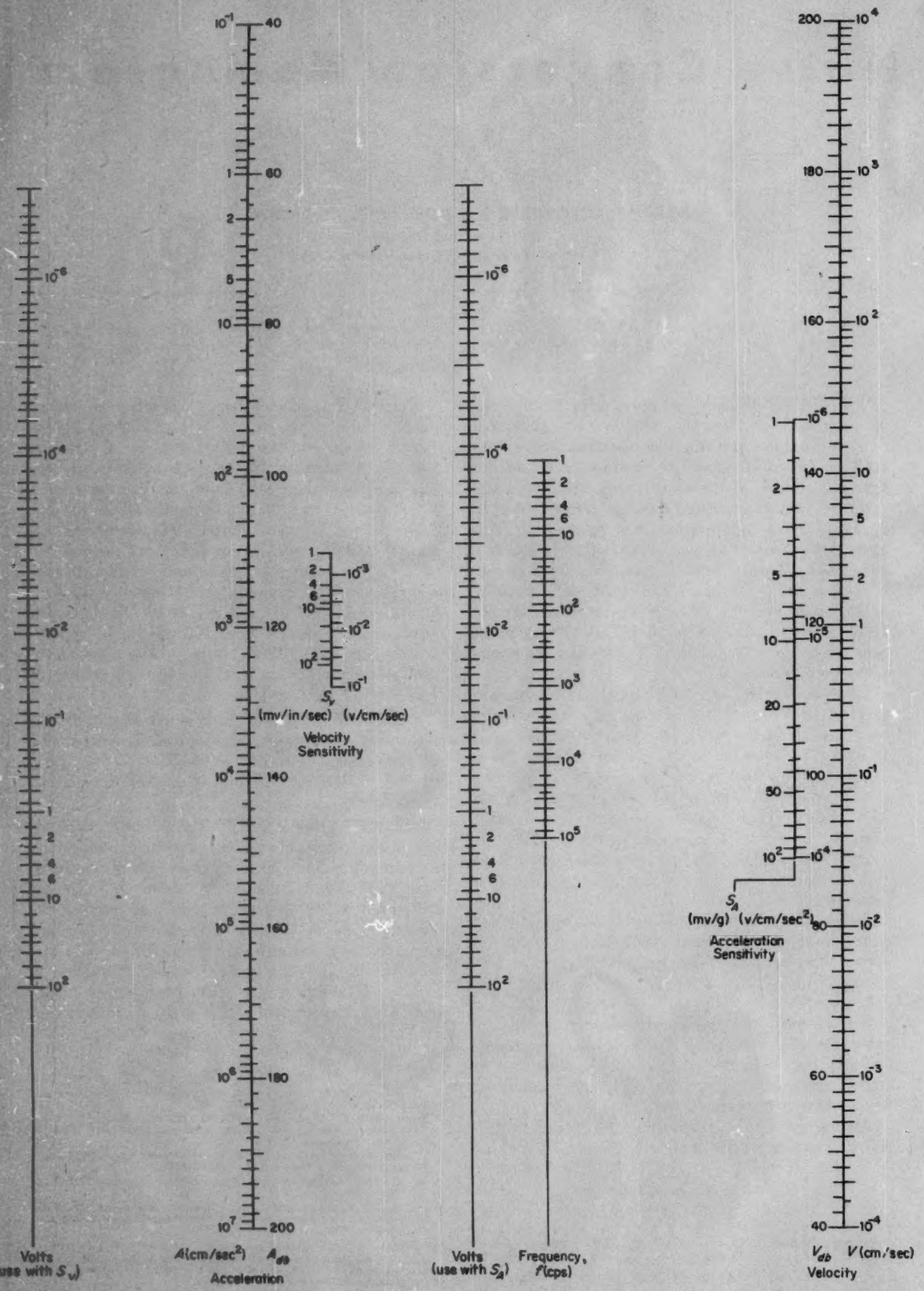
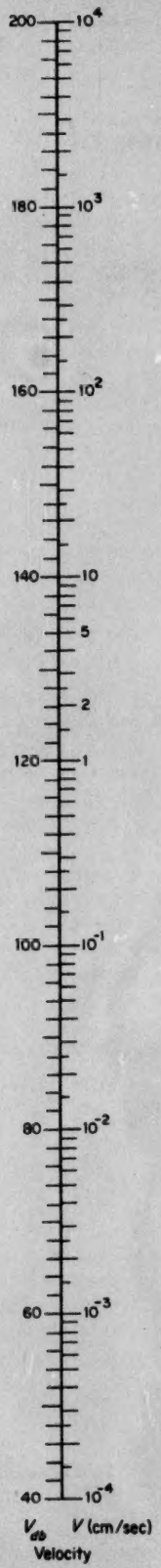
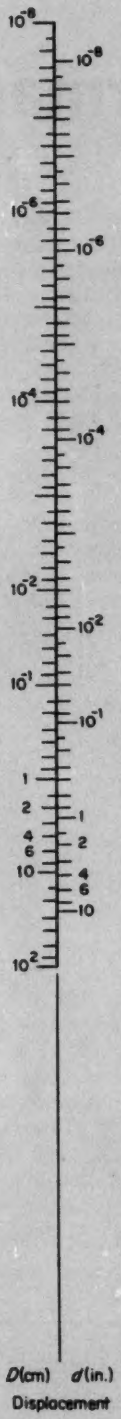

Volts (use with S_v)
A(cm/sec^2) A_{db}
Acceleration
S_v (mv/in/sec) (v/cm/sec)
Velocity Sensitivity
Volts (use with S_A)
Frequency, f(cps)
S_A (mv/g) (v/cm/sec^2)
Acceleration Sensitivity
V_{db} V(cm/sec)
Velocity

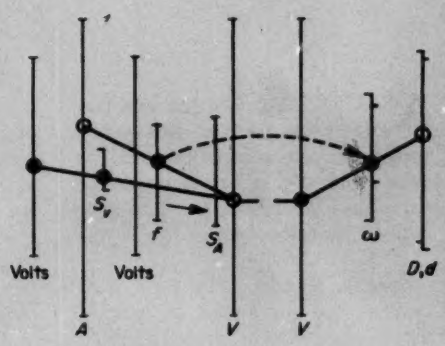




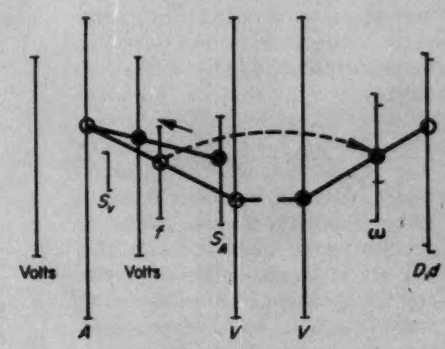
Nomenclature

A	= Acceleration, cm/sec^2
A_{db}	= Acceleration level, decibels
A_r	= Reference acceleration = 10^{-3} cm/sec^2
D	= Displacement, cm
d	= Displacement, in.
f	= Frequency, cps = $\omega/2\pi$
g	= Acceleration of gravity = 981 cm/sec^2
S_A	= Acceleration sensitivity
S_V	= Velocity sensitivity
V	= Velocity, cm/sec
V_{db}	= Velocity level, decibels
V_r	= Reference velocity = 10^{-6} cm/sec
v	= Volt
ω	= Angular velocity, radians/sec = $2\pi f$

Example 1



Example 2



Matching fan requirements and capabilities by use of

Fan Performance Indicators

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General Engineering Laboratory
General Electric Co.
Schenectady, N. Y.

AS A BASIC aid in the selection and design of fans, this article presents a correlation of performance data which will satisfy given sets of requirements without resort to generalities or rules-of-art.

Specific Speed: Extensively used in the fluid mechanics of rotating machines, the term "specific speed" characterizes a given fan or compressor design. Specific speed is a dimensionless number which is defined in terms of the fan head, flow, and rotor speed at one operating point. Expressed in fan variables commonly used, specific speed can be written

$$N_s = n \frac{Q^{1/2}}{(\Delta P)^{3/4}} \left(\frac{\rho}{0.075} \right)^{3/4} \quad (1)$$

where fan head has been replaced by pressure at a standardized inlet air density of 0.075 lb/cu ft. By the use of Equation 1, each point on the pressure-flow performance curve of a fan can be expressed in terms of corresponding specific speed. By plotting the static efficiency versus specific speed, a useful selection curve is obtained. Specific speed will range from zero to infinitity as the fan-performance curve ranges from zero flow to zero pressure. However, as shown in Fig. 1, only a narrow band of specific speeds corresponds to usable efficiencies. This band of values can be used to characterize the performance of each fan design.

The value of considering specific speed is that within broad limits, any fan will operate over the same range of specific speeds independent of the scale of the fan. Thus, by grouping a set of performance requirements in terms of a required specific speed and by comparing this with the specific speeds of various fan types, the most appropriate choice can be made. An example of this method is shown in Fig. 2.

Despite the usefulness of the specific-speed presentation, there is no assurance that the indicated fan design will physically fit into the space requirement.

The generality can be made that the fan size tends to be smaller as the specific speed increases. This statement, however, is of little value in comparing fans of roughly the same specific speed.

Specific Diameter: An additional

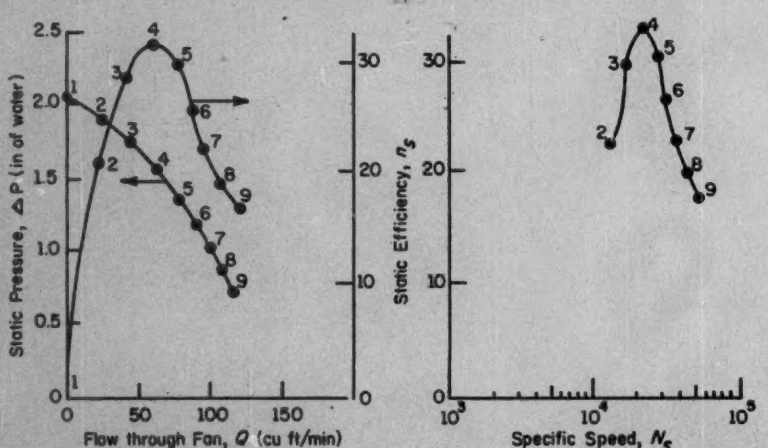

Fig. 1—Conversion of pressure-flow vs. efficiency to specific speed vs. efficiency.

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parameter is needed to define the fan size required to produce the desired pressure-flow without explicitly considering rotor speed. Such a parameter will be called specific diameter,

$$D_s = d_c \frac{(\Delta P)^{1/4}}{Q^{1/2}} \left(\frac{0.075}{\rho} \right)^{1/4} \quad (2)$$

For the purpose of selecting a fan to fit in a specified compartment, it has proved convenient to standardize d_c as the side of a square in a plane perpendicular to the axis of rotation which will just enclose the fan and housing. With this definition, fans with and without diffusers or scrolls may be compared and the optimum combination of fan rotor and housing determined.

By plotting specific diameter versus corresponding values of specific speed, a curve is obtained which explicitly describes the ability of that fan design to provide pressure and flow within the bounds of any space or speed limitation.

Solution Point and Fan Curve: The primary use of the specific variables N_s and D_s is in comparing fan designs with respect to their ability to perform within a set of rotor speed and volume restrictions.

These variables are uniquely suited for this purpose because they are both separable with respect to and linearly dependent on speed and size. Examine some of the fundamental relations of fan selection in the N_s-D_s plane.

Consider first a single fan design in relation to a specified pressure, flow, speed, and maximum characteristic diameter. By means of Equations 1 and 2, these four specifications convert into a single point in the N_s-D_s plane. This point is then compared with the fan design also plotted in the N_s-D_s plane to determine if the design is applicable. The method is illustrated in Fig. 3.

If the specification point falls *below* the fan-design curve, a solution with this design is not obtainable. However, if the solution point falls *on or above* the fan curve as in Fig. 3, the fan design in question will meet the requirements. When the solution point falls *on* the fan curve, the characteristic diameter of this particular fan design is just equal to the maximum which was specified. If the solution point is *above* the fan curve, the fan diameter will be less than the specified maximum.

Since D_s is directly proportional to fan diameter, the required fan size is obtained by a simple proportion of the D_s intercept along the fan curve to the D_{s0} solution point value. Using values corresponding to Fig. 3,

$$d_{c\,\min} = d_{c0} \frac{D_s(\text{intercept})}{D_{s0}}$$

$$= 1 \frac{6 \times 10^{-2}}{7.93 \times 10^{-2}} = 0.756$$

In this example, the solution was determined by the intercept of a constant specific-speed line through the solution point and the fan curve. This method will yield the smallest fan of the particular design family which, when operating at the desired rotor speed, will meet the pressure and flow specifications.

If, rather than the smallest fan, the fan running at the lowest speed is desired, then the solution is given by the intercept of a constant D_s line through the solution point with the fan curve. The fan prorated from this point will be just equal to maximum specified size and will run at the lowest speed which can develop the desired performance. The minimum speed can be found immediately by the ratio of the intercept to solution-point specific speeds times the solution-point rotor speed. For the example in Fig. 3,

$$N_{\min} = n_0 \frac{N_s(\text{intercept})}{N_{s0}}$$

$$= 3450 \frac{1.7 \times 10^4}{2.55 \times 10^4}$$

$$= 2300$$

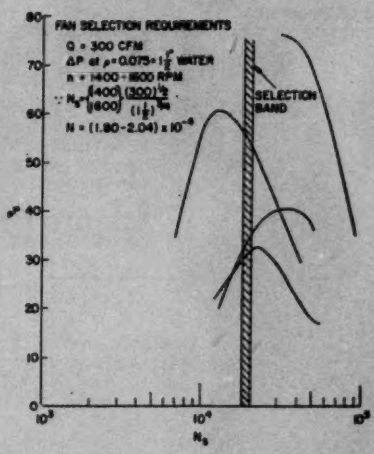

Fig. 2—Fan selection based on efficiency at design specific speed.

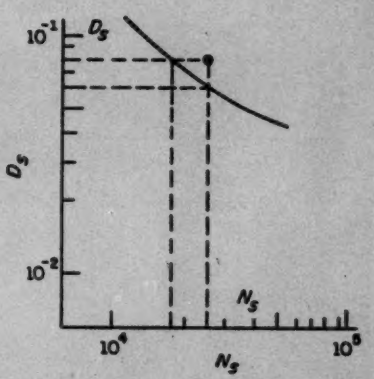

Fig. 3—Comparison of system requirements with fan performance.

The examples illustrate the manner of determining the smallest size or lowest speed fan of a given design which will deliver a certain pressure flow. Intermediate solutions between these extremes can be obtained by prorating any point along the fan curve between the horizontal and vertical intercepts through the solution point.

Square-Law Resistance: In many fan applications, the load approximates a square-law resistance. That is, the pressure required by the load is proportional to the square of the flow. The flow through the fan and load system stabilizes at the intercept of the fan and load curves.

In the N_s-D_s plane, the load line is simply a straight horizontal line (at constant D_s). The D_s value for the entire line can be determined by inserting the pressure and flow

Nomenclature

- a = Local speed of sound, fpm
- d = Rotor diameter, hydraulic diameter, ft
- d_c = Characteristic diameter of fan package, ft
- D_s = Specific diameter, $d_c = \frac{(\Delta P)^{1/4}}{Q^{1/2}}$
- n = Rotor revolutions per minute, rpm
- N_s = Specific speed
- ΔP = Static pressure developed by fan, in. of water
- Q = Volume flow through fan, cfm
- η_s = Static efficiency
- ρ = Weight density, lb/cu ft

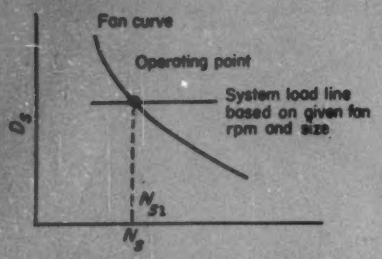

Fig. 4—Square-law load represented by a horizontal line in the specific-variables plane.

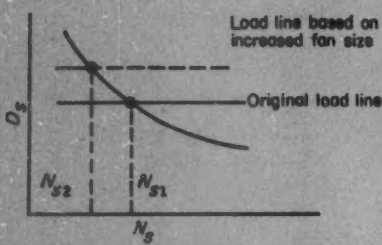

Fig. 5—Operating point flow increased by increasing fan size.

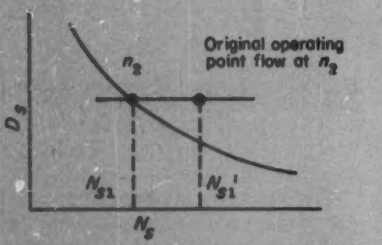

Fig. 6—Line-flow load, represented by a value of specific speed, is directly proportional to fan speed. Since the specific speed of the operating-point flow is independent of actual fan speed, the operating-point flow is directly proportional to fan speed.

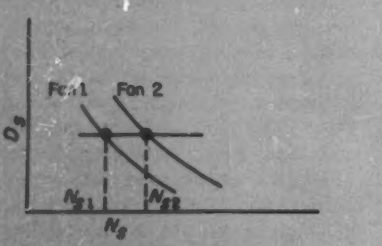

Fig. 7—Operating flow maximized by selecting the fan design which intercepts the load line at the lowest specific speed.

requirement for any one point. Values along the line at lower specific speeds correspond to higher flows through the load and at higher specific speeds to lower flows.

A frequent fan problem involving a fixed load is the desire to obtain an increase in flow starting from some base point. It is assumed that a fan has been tested and the fan-performance curve as well as the operating point with the system load is known. Fig. 4 illustrates the geometry in the N_s-D_s plane.

There are in general three methods of increasing the flow through the load: Increasing the fan size, increasing the fan speed, or changing the fan design. Consider each in turn.

Since D_s and fan size are directly proportional, an increase in fan size simply shifts the constant D_s load line a corresponding increment, Fig. 5. The load line now intercepts the fan curve at a lower than original value of N_s which indicates an increased flow.

If it is possible to increase the rotor speed of the original design, the system flow will increase in direct proportion to the rotor speed, Fig. 6. Since the location of the load line is independent of speed, the interception of the load line and fan curve remains constant with speed. Thus $N_{s1} = N_{s2}$, and n_1/n_2.

If it is not possible to increase rotor speed or fan size, an increase in flow requires a superior fan design. By comparing several fan designs in the N_s-D_s plane the fan curve which intercepts the load line at the smallest value of specific speed will give the highest flow, Fig. 7.

ASME Paper No. 61-Hyd-6 "A Correlation of Fan Performance for Solving Selection Problems," presented at the joint ASME-EIC Hydraulic Conference, Montreal, Canada, May, 1961, 12 pp.

techniques

Design Technique for Feedback Compensation

G. J. Thaler, J. D. Bronzino, and D. E. Kirk, U. S. Naval Postgraduate School, Monterey, Calif.

Design of feedback compensation for feedback control systems. Design is reduced to an equivalent problem in cascade compensation by the use of simple, block-diagram manipulation. In conjunction with this block-diagram manipulation, the use of the root locus method provides a particularly convenient means of analysis and design. For simple systems, these methods permit derivation of simple equations as for the tachometer. For more complex systems, the choice of a compensation path and a suitable compensator is simplified and placed on a more logical basis. Nonlinear systems may also be treated with this technique. Design of linear compensators for nonlinear systems is also feasible.

AIEE Paper No. 61-752, "Feedback Compensation, a Design Technique," presented at the AIEE Summer General Meeting, Ithaca, N. Y., June, 1961, 10 pp.

materials

Copper-Beryllium Strip At High Temperatures

K. G. Wikle and N. P. Sarle, Brush Beryllium Co., Elmore, Ohio

Investigation of the effects of exposing hardened (AT and HT) copper-beryllium alloy 25 (1.91 per cent beryllium, 0.26 per cent cobalt) at temperatures from 100 to 1150 F for 0 to 120 hr.

This alloy demonstrates good stability of tensile properties up through 500 F for the time periods investigated, and this could be considered as a limiting service temperature for exposure and use up to 100 to 120 hr. As discussed, it would be necessary to use stress levels significantly below the short-time tensile yield strength or proportional limit in order to avoid excessive creep or the possibility of creep-rupture.

Reheating hardened strip from 100 to 600 F caused a renewal of precipitation strengthening effects in both AT and HT material and a possibility of strain hardening during testing of AT material up to 600 F. The original and induced hardening limited elongation up to 600 F. The AT material was stronger than the HT material above 700 F.

This work further demonstrated that maximum hardening can be accomplished either by long-time aging at about 500 F or possibly by a shorter double-aging treatment.

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P.S. For further help in writing John's answer, send for the new Amweld products catalog. Or if you have something more specific in mind, don't hesitate to send your specifications, a blueprint, or a sketch, so Amweld can quote for your cost evaluation!

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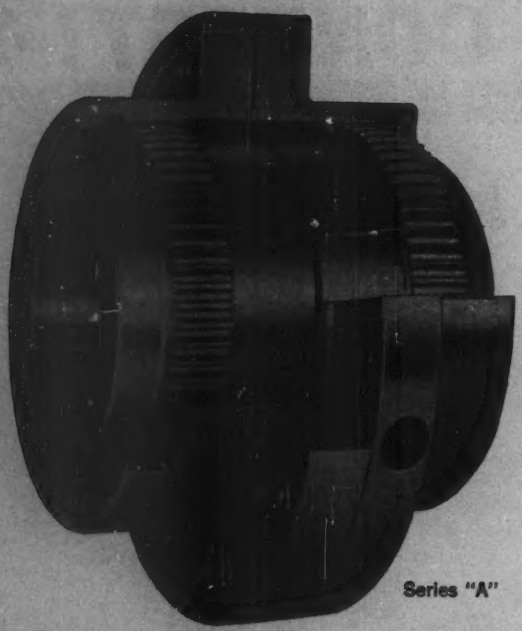

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4A	4¼	225	6,000
4½A	4¾	365	5,300
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ASTM Preprint No. 79, "Properties of Hardened Copper-Beryllium Strip after Exposures to Elevated Temperatures," presented at the 64th Annual Meeting, Atlantic City, N. J., June, 1961, 20 pp. Preprint price, 50 cents.

Hot Hardness of Aluminum Compounds

E. R. Petty, Aluminum Laboratories Ltd., Banbury, Oxon, England

Results of tests on 21 binary intermetallic compounds of aluminum from room temperature to 600 C:

1. The hardness of some intermetallic phases has been shown to correlate with their melting temperature and heat of formation, all these properties no doubt being related to the strength of the interatomic bonds and crystal structure.
2. It has been shown that hardness and brittleness are not synonymous and that there is scope for the quantitative study of brittle behavior in intermetallic compounds. The brittleness of various silicides and borides increases with the interatomic bond strength. This may also be true for intermetallic compounds generally.
3. The hardness results on intermetallic phases have shown that there are two important groups from a practical viewpoint: Those that remain hard and brittle up to ≈500 C, and those that become soft and relatively plastic at intermediate temperatures. This allows the behavior at elevated temperatures of alloys containing the different phases to be predicted.

Institute of Metals Paper No. 2070, "Hot Hardness and Other Properties of Some Binary Intermetallic Compounds of Aluminum," Journal of the Institute of Metals, Vol 89, 1960-61, pp. 343 to 349.

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AIEE—American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., papers 50 cents to members, one dollar to nonmembers.

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., papers 50 cents to members, one dollar to nonmembers.

ASTM—American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.

The Institute of Metals, 17 Belgrave Square, London S.W. 1, England.

Helpful Literature for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Electronic Transformers

Advantages of electronic transformers for military applications are pointed out. Contains sections on stock models. Effect of design parameters on construction is included, along with a table and diagrams showing the characteristics of common rectifier circuits. Bulletin GEA-7121, 28 pages. General Electric Co., Schenectady 5, N. Y.

Circle 501 on Page 19

Rotary Pumps

Provides information on Series K pumps, including updated engineering details and performance charts for ten sizes of Series K units. Also contains data on Series KE units. Revised Bulletin F-4176, 8 pages. Roper Hydraulics Inc., Commerce, Ga.

Circle 502 on Page 19

Instrument Gages

Includes detailed descriptions of compact, easy-to-read V5 gages for indicating draft, pressure, differential gas pressure, and temperature and pneumatic impulses from transmitters. Discusses diaphragm, bellows, and helix types. Bulletin 321.11, 12 pages. Republic Flow Meters Co., 2240 Diversey Parkway, Chicago 47, Ill.

Circle 503 on Page 19

Laboratory Instruments

Details entire line of laboratory instruments. Pictured and described are electrometers, micro-microammeters, a microvoltmeter, regulated high-voltage supply, and high-megohm bridge. Form 35M, 32 pages. Keithley Instruments Inc., 12415 Euclid Ave., Cleveland 6, Ohio.

Circle 504 on Page 19

Paper in Product Design

Describes uses and advantages of paper as a material in product design. Covers a wide application range, including conductivity papers for facsimile transmission, cork-impregnated gasket paper, saturating-base papers for electronic laminates, and papers for filtering air, oil, and fuels. "Creative Imagination in the Development of Technical and Industrial Specialty Papers," 12 pages. Knowlton Brothers, Watertown, N. Y.

Circle 505 on Page 19

Pin-Type Fasteners

Covers studs, dowels, and high-alloy shear-proof pins, in addition to standard solid-grooved pin fasteners. Lists recommended pin diameters for various shaft sizes and torque values transmitted by pins in double shear. Minimum single-shear values are also listed in a separate table for pins of various metals. Covers finishes available and gives the dimensions and tolerances for the entire line. "Grooved Fasteners," 4 pages. Driv-Lok Sales Corp., 77 Park Ave., Sycamore, Ill.

Circle 506 on Page 19

Liquid Sealant

Describes Loctite sealant, showing applications and methods of application, selection of proper grade. Shows use with fasteners, with bearings, and as a sealant. Also includes technical data and specifications met. Form 204c, 8 pages. American Sealants Co., Hartford 11, Conn.

Circle 507 on Page 19

Gear and Pinion Units

Line of integrally die-cast gear-and-pinion combinations is detailed by drawings and tables showing pitch, number of teeth, pitch diameter, and other dimensions. More than 200 combinations include gear (with hub and hole), gear and pinion (with hole or shaft), flanged pinion (with hole or shaft), cup gear and pinion (with hole or shaft), cup gear and hub (with hole), plus gears and pinions with special features. Catalog 3001-C, 10 pages, Gries Reproducer Corp., 400 Beechwood Ave, New Rochelle, N. Y.

Circle 508 on Page 19

Adjustable Sequence Timer

Data on Micro-Adjustable sequence timer 4-23 includes operational instructions, methods of adjustment, construction features, accuracy data, switch specifications, types of cams, dimensions, and environmental standards. 4 pages. Space Instrumentation Div., Technology Instrument Corp., 533 Main St., Acton, Mass.

Circle 509 on Page 19

Chemical Process Pumps

Includes information on Model 3195 chemical-process pumps, available in 11 sizes. Bearing-life expectancy, shaft deflection, interchangeability charts and diagrams, performance, application, and dimension data are covered. Bulletin 725.1, 16 pages. Goulds Pumps Inc., 225 Black Brook Rd., Seneca Falls, N. Y.

Circle 510 on Page 19

Fluid Motors

Describes hydraulic Orbit motors which provide speeds from 10 to 800 rpm and torques to 3300 lb-in. Covers advantages and construction, and principles of operation. Includes two-page selection guide. Catalog 2361, 8 pages. Char-Lynn Co., 2843 26th Ave., S., Minneapolis 6, Minn.

Circle 511 on Page 19

Designing with Phenolics

Gives guidelines for designing with phenolic molding compounds. Lists typical applications and design properties of these materials, and compares their costs with those of metals. Bulletin CDC-394, 6 pages. Chemical Materials Dept., General Electric Co., One Plastics Ave., Pittsfield, Mass.

Circle 512 on Page 19

Wire-Wound Potentiometers

Describes single-turn, wire-wound, linear, nonlinear, and sine-cosine precision potentiometers. Contains performance data on 11 models, and an explanatory section which describes special features in detail. 6 pages. Fairchild Controls Corp., 225 Park Ave., Hicksville, L. I., N. Y.

Circle 513 on Page 19

Worm-Reduction Gears

Covers universal-mounting types with 1⅛, 1¾, 2¼, and 3-in. centers. Contains horsepower rating tables, selection data, specifications. Includes standard, inverted, vertical, vertical agitation, D-mounting, and gear case-mounting units. Publication 571 B, 16 pages. Crofts U. S. A. Inc., 2542 W. Peterson Ave., Chicago 45, Ill.

Circle 514 on Page 19

Pressure Transducers

Ultradyne pressure transducers provide accurate measurements with ambient temperatures to +1000 F and have high resistance to nuclear radiation. Types 411, 412, and 413 are described, including specifications on the transducer, transmitter, and instrument chassis. 4 pages. Consolidated Controls Corp., Bethel, Conn.

Circle 515 on Page 19

Leather Packings

Packings are available in a variety of sizes and shapes including "U," cup, Vee, flange packings, gaskets, and washers. Catalog offers tannage and impregnation information as well as design data that include standard design dimensions, installation procedures, allowable clearances, and ordering information for each type of packing. Form AD-186, 12 pages. Garlock Inc., Palmyra, N. Y.

Circle 516 on Page 19

Design of Welded Hangers

Analysis of stresses in brackets, hangers, or other structures, arc-welded to a cylindrical element, must be carried out carefully. Bulletin gives basic formulas to be used in determining these forces; presents examples to illustrate. "Studies in Applied Weldesign 1204.4," 4 pages. Lincoln Electric Co., 22801 St. Clair Ave., Cleveland 17, Ohio.

Circle 517 on Page 19

Drafting Machines, Tables

Many Nestler drafting tables, which range in size from table-top and portable units to large, custom installations, are obtainable with a counterweight system that permits rapid adjustment from low to high board level in any angle from horizontal to vertical. Pictures and brief descriptions of five tables and kit, and seven drafting machines are included. Scales and various accessories are also listed. 4 pages. Ozalid Div., General Aniline & Film Corp., Johnson City, N. Y.

Circle 518 on Page 19

Materials Data

First in a series of engineering and design briefings on materials covers sintered titanium parts. Future issues will cover scientific materials selections, advanced metal applications, fiber metallurgy, and tungsten composites. "Materials Scope," 2 pages. Mechanical Research Div., Clevite Corp., 540 E. 105th St., Cleveland 8, Ohio.

Circle 519 on Page 19

Governors, Switches

Describes units with from one to six switching elements. Points out applications, drive and mounting styles, speeds, and other specifications. Also covers accessories, governor bodies, connector variations, and multidrive units with 1 to 18 switching elements. Bulletin 604, 12 pages. Synchro-Start Products Inc., 8151 N. Ridgeway Ave., Skokie, Ill.

Circle 520 on Page 19

Slip Rings; Brush Assemblies

Describes and illustrates slip rings, brush assemblies, rotary switches, and commutators. Includes applications, classifications, line drawings of typical assemblies. 16 pages. Slip Ring Co. of America, 3612 W. Jefferson Blvd., Los Angeles 16, Calif.

Circle 521 on Page 19

Laminated Plastics

Presents 11 different hints for designing with laminated plastics, each with a detailed drawing. Also provides data on grades and properties of laminated plastics, and lists techniques for machining. Form S1060, 8 pages. Synthane Corp., Oaks, Pa.

Circle 522 on Page 19

Reproduction Processes

Provides latest industrial reproduction processes and materials data on a periodic basis. Concerned chiefly with "how-to" phase of industrial reproduction. First issue covers drafting on Kodagraph reproduction films. "Kodak Compass," 6 pages. Sales Service Div., Eastman Kodak Co., Rochester 4, N. Y.

Circle 523 on Page 19

Plastics Properties; End Uses

Revised Plastics Fact File describes the properties and typical end uses of Lustrex styrene, Monsanto polyethylene, Opalon vinyl chloride, and Lustran SAB and SAN molding and extrusion compounds. Also features general information about the forms, typical uses, and characteristics of fabricating, extruding, calendering, and laminating materials; industrial, textile, surface and paper coating resins, adhesives, and intermediates. 16 pages. Department FF, Monsanto Chemical Co., Springfield 2, Mass.

Circle 524 on Page 19

Industrial Casters

Covers 17 series of truck casters ranging in load capacity from 125 to 15,000 lb each. Provides illustrations and information on special application casters including V-grooved, spring-action, grease-sealed, and scaffold types. Seven types of wheels are shown in cut-away views. Form 7161, 4 pages. Dept. PR-327, Faultless Caster Corp., Evansville 7, Ind.

Circle 525 on Page 19

Air-Control Products

Covers air-control products for automating in-plant operations and for component use in new products. Describes cylinders, valves, rotating joints, filters, regulators, quick-acting couplers, and hose fittings. Includes information on dimensions, flow rates, and operating pressures, whenever applicable, as well as a number of typical air-control circuits. Catalog 125, 48 pages. A. Schrader's Son, Div., Scovill Mfg. Co. Inc., 470 Vanderbilt Ave., Brooklyn 38, N. Y.

Circle 526 on Page 19

Magnetic Drives

Covers magnetic adjustable-speed drives, available in ratings from 50 through 2500 hp. Describes basic components, theory of operation, controls, and design features. Also lists applications. Bulletin 2650, 6 pages. Dept. P, Louis Allis Co., 427 E. Stewart St., Milwaukee 1, Wis.

Circle 527 on Page 19

Braided Hose

Describes flexible bronze wire-braided hose containing an inner core of Teflon. In addition to specifications and applications, data are given on attachable, reusable fittings. Bulletin 29, 4 pages. Atlantic Metal Hose Co. Inc. 308 Dyckman St., New York 34, N. Y.

Circle 528 on Page 19

Bronze Alloys

Forty-two Ampcoloy specification bronzes plus heat-treated variations are classified in 11 basic categories, including commercial aluminum bronzes, tin bronzes, manganese bronzes, and high-conductivity alloys. Lists nominal chemical and average physical properties, available forms, government and society specifications met, and some typical applications. Bulletin G-61, 10 pages. Ampco Metal Inc., Box 2004, Milwaukee 1, Wis.

Circle 529 on Page 19

Compression Tube Fittings

Presents 25 items of Ridg-lok tube-fitting line with illustrations and dimensions. Fittings have reversible ferrule to eliminate putting them in backward, are for tubing of 1/16 through 1 in. O. D. Catalog 4323, 20 pages. Parker Fittings & Hose Div., Parker-Hannifin Corp., 17325 Euclid Ave., Cleveland 12, Ohio.

Circle 530 on Page 19

Beryllium Copper Rod

Includes data on tensile strength, yield strength, elongation, Rockwell hardness, and electrical conductivity for Berylco 10, 25, and 50 alloys. Other properties such as modulus of elasticity, coefficient of thermal expansion, density, and endurance strength are also listed. Bulletin R-1200-A, 8 pages. Beryllium Corp., Reading, Pa.

Circle 531 on Page 19

Pilot Valves

Solenoid-operated fluid-power pilot (directional) valves are suitable for pressures to 3000 psi. Information includes construction features, dimension data, specification data, flow diagrams, ASA symbols, and type designation for all sizes of the valves. Bulletin 80125, 4 pages. Oilgear Co., 1570-Q W. Pierce St., Milwaukee 4, Wis.

Circle 532 on Page 19

Silicone Fluids

Differentiates among available grades of silicone fluids according to viscosity, and classifies them on the basis of physical properties. Contains a physical-data summary chart which permits easy identification of major grades of materials available, and a silicone-fluid selector in which available silicone-fluid grades are identified by major application areas. Technical Data Book S-9, 20 pages. Write on company letterhead to Silicone Products Dept., General Electric Co., Waterford, N. Y.

High-Temperature Alloys

Features a series of 11 steels and alloys, each with its own individual leaflet, together with a general booklet on high-temperature alloys. All the materials are treated in the general booklet, and each steel or alloy is treated in detail in the individual leaflet. Booklet classifies the families of high-temperature steels and alloys into iron base, nickel base, iron-nickel base, cobalt base, and the cobalt-chromium-iron-nickel alloys. Also included are high-temperature alloy graphical charts, test data, machining data, and test procedures. 80 pages. Write on company letterhead to Allegheny Ludlum Steel Corp., Oliver Bldg., Pittsburgh 22, Pa.

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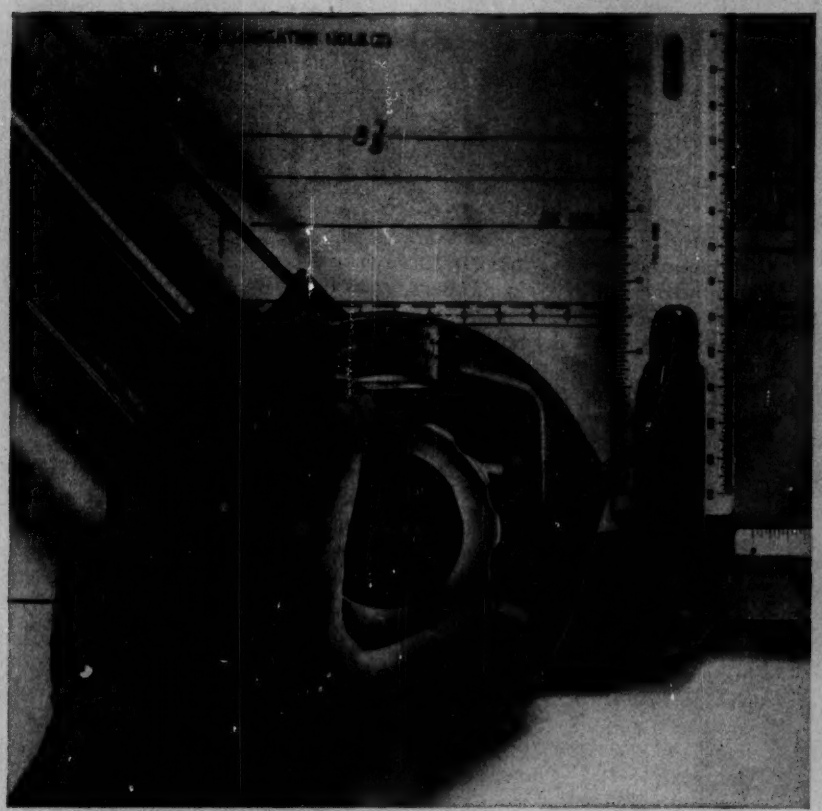

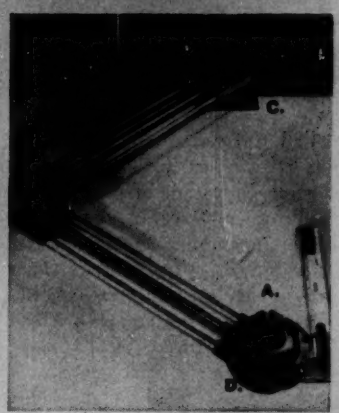

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Circle 253 on Page 19

New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Handle Assemblies

for use on lightweight, portable units

Econoline handle assemblies consist of a Mylar-protected, gold or silver-colored insert laminated to a vinyl handle. Assemblies are suitable for attachment to a variety of lightweight portables, such as fans, corrugated boxes, tool chests, and

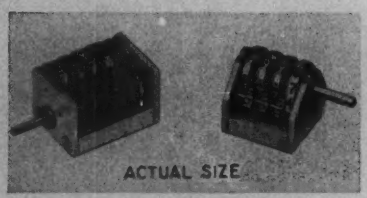
small instruments. Hardware of steel or brass, in any 12 finishes, fastens by means of prongs bent on the undersurface of the mounting area. Assemblies can be ordered in any length. They are also available with a simulated-leather texture instead of the insert; this version is produced in 13 standard colors. Precise color match can be specified for 5000 or more assemblies. Philadelphia Handle Co., 1643 Haddon Ave., Camden 3, N. J.

Circle 533 on Page 19

Subminiature Counters

have digits 0.075 in. high and 0.045 in. wide

Model 1005 and 1006 subminiature counters have drums 0.288 in diam. Digits are 0.075 in. high by 0.045 in. wide, and counter is reversible. Model 1005 has a 200:1 gear reduction; pitch of the gears in the train is 120. Package size is 7/16 in. wide by 5/8 in. long by 29/64 in. high. Maximum input speed is 5000 rpm. Model 1006 package



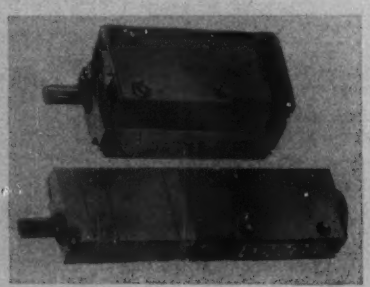
size is 7/16 in. wide by 15/32 in. long by 29/64 in. high. Frames are anodized aluminum, shafts are stainless steel, and bearings are Oilite. For military applications, drums are anodized aluminum with engraved digits. For commercial use, Model 1006 is available with Lexan molded drums and pinions. Haydon Instrument Co., 17 Brown St., Waterbury 20, Conn.

Circle 534 on Page 19

Miniature Gear Motors

in end or side-mounted types

Permanent-magnet Type VS dc gear motors provide up to 35 oz-in. torque continuous duty, in a package having a frontal area as small as 0.4 sq in. Two configurations are available: End-mounted reducer provides 62 ratios from 7.88:1 to 25,573.65:1; side-mounted unit provides a choice of 27 ratios from 26.93:1 to 2,511.84:1. End-mounted reducer and VS motor is 7/16 x 7/8 x 3 3/4 in. maximum length, depending on ratio chosen; typical weight is 2.5 oz. Side-mounted reducer and VS motor is 7/8 x 7/8 x 2 1/4 in. long; typical



weight is also 2.5 oz. Units meet appropriate MIL specs. Standard motor has 13 standard armatures for up to 50 v dc; motor is rated 0.0025 hp at 8000 to 17,000 rpm. Globe Industries Inc., 1784 Stanley Ave., Dayton 4, Ohio.

Circle 535 on Page 19

Photoconductive Cell

miniature unit measures tungsten or daylight

Series I miniature photoconductive cell closely approximates the spectral perception of the human eye. Cadmium - sulfide cell measures either tungsten or daylight over a wide range of color temperatures through variation in its conductance. Series will contain six distinct types designed for both normal and low-impedance, transistor-type applications and in both side and end-view, hermetically sealed

configurations. Clairex Corp., 8 W. 30th St., New York, N. Y.

Circle 536 on Page 19

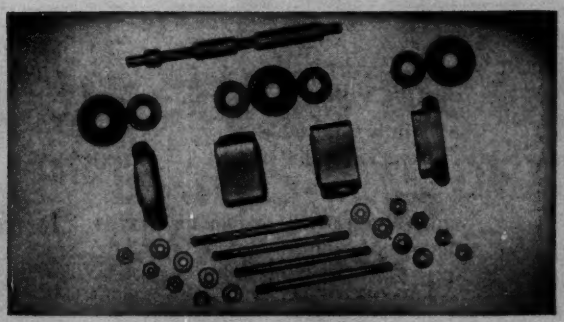
Instrument Bearings

have extra-thin cross-sections

Bearings with extra-large bore-to-OD ratios, permitted by thin cross-sections, allow new shaft-to-housing relationships. Units are of instrument quality, and are Type 440C stainless steel. Retainers have plastic crown design with lubricant absorption properties. Bearings are ABEC Class 5 and better. Combinations of bore/OD dimensions

Do the air valves you buy include these quality features?

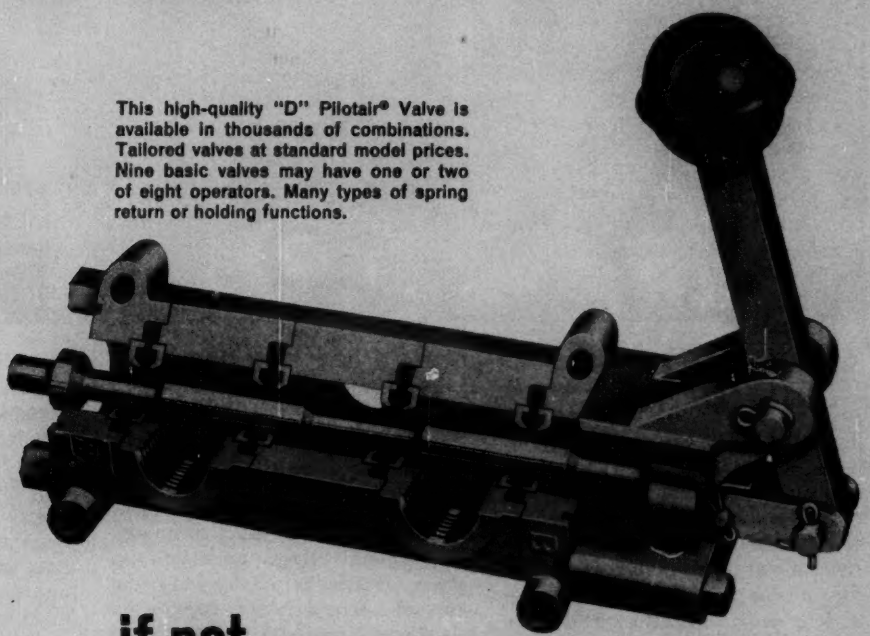
SEAL—Exclusive, triple-supported seals permit interference fit of spool for extra-tight closure with minimum wear. Usual damage to conventional "O" rings by moving spool is eliminated.



SIMPLICITY—Uncomplicated parts mean long life and easy servicing. Common parts are used extensively to simplify stocking or repair.

FLEXIBILITY—Modular Construction. Operators, mounting holes and ports may be independently rotated in 90° steps. Operator may be on either or both ends.

This high-quality "D" Pilotair® Valve is available in thousands of combinations. Tailored valves at standard model prices. Nine basic valves may have one or two of eight operators. Many types of spring return or holding functions.

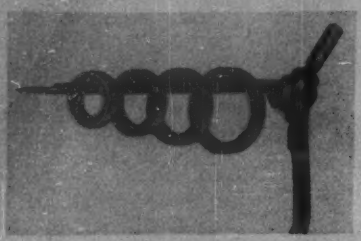


if not, the chances are your maintenance costs are higher than necessary. For more information about quality Fluid Circuitry Controls for trouble-free automation, ask for Catalog A4-75.01.

See the Yellow Pages under Cylinders for the Name of Your Local Distributor, or refer to Sweet's Catalog, Product Design File.

WESTINGHOUSE AIR BRAKE COMPANY

INDUSTRIAL PRODUCTS DIVISION, WILMERDING, PENNSYLVANIA



include: 0.3750/0.6250, 0.5000/0.7500, 0.6250/0.8750, and 0.7500/1.000 in. Widths are standard 0.1652 in. **New Hampshire Ball Bearings Inc.**, Rte. 202, Peterborough, N. H.

Circle 537 on Page 19

Clear Adhesive

is nonstaining on light-colored vinyls

M6105, clear adhesive bonds vinyl to vinyl or vinyl to metal. A synthetic resin-based adhesive, it prevents solvent reaction by plasticizer migration and is nonstaining on lightest-colored vinyls. On a two-surface-coat application, drying time before bonding varies from a few minutes to 30 min. In some instances, a one-surface coat can produce a strong bond. Adhesive can be applied by brush, spray, or roller. **United States Rubber Co.**, 1230 Avenue of the Americas, New York 20, N. Y.

Circle 538 on Page 19

Self-Locking Fastener

is clip-on unit

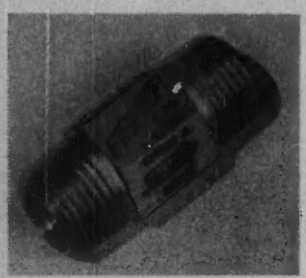
Type LHA4972 clip-on self-locking fastener has aircraft applications such as attachment of flooring, sound proofing, and fairings. It can also be used for other types of sheet metal or glass-fiber assemblies for missile and electronic end-use as long as 0.020-in. thickness of the clip can be tolerated between the mating surfaces. For such applications it replaces fixed or floating anchor or plate-type nuts which must be riveted to the sheet. Locating eyelet formed on the base plate snaps firmly into hole drilled or punched in the sheet. First unit is carbon steel in No. 10-32 size. Locking torque and tensile strength meet MIL-N-25027. **Elastic Stop Nut Corp. of America**, 2330 Vauxhall Rd., Union, N. J.

Circle 539 on Page 19

In-Line Valve

is fully adjustable from 50 to 5000 psi

Series 104600 in-line valve for use in hydraulic, fuel, or pneumatic systems automatically stops flow to gage at excess pressures. Unit is available in aluminum and stainless steel, and is fully adjustable from 50 to 5000 psi. Valve is machined from ⅞-in. hexagon stock and is 2 in. long, including ½-14 NPT male connections at each end. **Fisher Controls Inc.**, 1754 22nd St., Santa Monica, Calif.



Circle 540 on Page 19

Subminiature Switches

have only two moving parts

Cricket subminiature, precision, snap-action switches have uniform stress distribution throughout the contact-carrying leaf spring to reduce metal fatigue. This results in long switch life with high reliability and uniform operation. Line includes basic single-pole, double-throw switch complete with a series of lever-type actuators and toggle or pushbutton-operated assemblies. Switches are rated 5.0 amp at 125-250 v ac on inductive and resistive loads, 4.0 amp at 30 v dc on resistive loads, or 2.5 amp at 30 v dc on inductive loads to 50,000-ft altitudes. Basic switch weighs less than 0.080 oz. Switches have only two moving parts—leaf spring and pushbutton to actuate it. **Contacts & Specialties Div., Fansteel Metallurgical Corp.**, North Chicago, Ill.

Circle 541 on Page 19

Temperature-Indicating Coatings

in 14 new temperature ratings

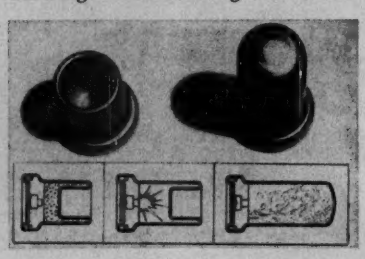
Fourteen new Tempilaq temperature-indicating coatings bring the total number to 100, covering the range from 100 to 2500 F in systematically spaced intervals. New ratings include: 106, 119, 131, 144, 156, 169, 182, 194, 206, 219, 231, 244, 256, 269 F. **Tempil Corp.**, 132 W. 22nd St., New York 11, N. Y.

Circle 542 on Page 19

Propellant-Actuated Device

is used as emergency energy source and as a buffer

Telecartridge is a metal cup telescoped within itself. When subjected to an internal pressure, it expands to full length, and cup does not rupture. Unit can be used as a self-contained, sealed, emergency energy source or as a cup to mate with a moving piston, providing a one-shot buffing device. Wide range of energy ratings is available by variations of physical size, charge, and case material. Positive sealing is provided—smoke, flash, flame remain within the cartridge. Typical applications include separation bolts, actuator, ejector, and dispenser. Cartridge diameter ranges from 0.38



TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

One in a series of technical reports by Bower

BEARING BRIEFINGS

ROLLER BEARING LIFE AND CAPACITY LINKED TO STRESS DISTRIBUTION

These reproductions of photoelastic studies contain important evidence for every engineer and designer concerned with the performance and selection of roller bearings. In these photographs, the alternate dark and light areas, called fringes, indicate not only the magnitude of stress but also the stress distribution. The photographs were taken by Bower Research Engineers during a study of stress distribution in roller bearings.

The subjects represent rollers and raceways of two roller bearings under identical loads. The illustration at the left shows a roller of conventional design. The illustration at the right shows a Bower "Profiled" roller. That is, the roller is precision ground with a large radius generated along the body of the roller—a predetermined and controlled distance from each end.

The conventional roller photo (left) clearly shows how, under load, stress concentration builds up in and near the roller ends. This is called edge-loading. Such areas of concentrated stress are the breeding grounds for metal fatigue and eventual bearing failure.

In the photo of the "Profiled" roller (right) stress lines can be seen uniformly distributed across the whole length of the roller and raceway. There are no points of excessive stress concentration, consequently no starting points for early fatigue. Such a "Profiled" roller exhibits a great advantage in improved load carrying capacity, a most important bearing requirement.

Under actual operating conditions, Bower "Profiled" roller bearings show a considerably longer life at higher speeds and under greater loads than conventional roller bearings.

Because of this, and of other Bower features to be discussed in later technical reports, we suggest that you consider the advantages of Bower bearings in satisfying your future bearing requirements.

★ ★ ★ ★

Bower engineers are always available, should you desire assistance or advice on bearing problems. Where product design calls for tapered roller bearings or journal roller assemblies, Bower makes these also in a full range of types and sizes.

BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION — FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN

to 2.8 in. Aircraft Armaments Inc., Cockeysville, Md.

Circle 543 on Page 19

Differential Brake Valve

for use with brake fluids or hydraulic oils

No. 1260-1 differential brake valve, eliminates need for nonslip differentials on material handling, mobile, and off-the-road vehicles. Device has two normally open, spring-return, two-way valves with a common pressure port to which the master brake cylinder is connected.

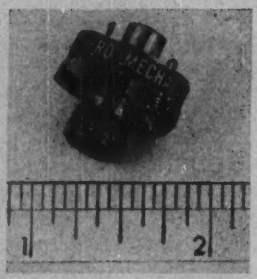
Each of the two cylinder ports is connected to a brake cylinder of one of the two drive wheels of a vehicle. By depressing a pushbutton, operator can shut off flow of brake fluid to the wheel having traction in a case where one drive wheel is spinning. Operator then can depress his brake pedal and lock the spinning wheel only, enabling the vehicle to proceed under its own power, with one wheel driving, until both wheels again are in traction. Valve is available for use with hydraulic oils or brake fluids and can be installed easily on any hydraulic brake system. **Sarasota Precision Products Inc.**, 5727 McIntosh Rd., Sarasota, Fla.

Circle 544 on Page 19

Pressure Switch

subminiature unit is accurate to ±2 psig

Model 6289 subminiature pressure switch is suitable for applications in electronic pressurization alarms, missiles and aircraft pressure systems. Switch withstands 50g shock, 15g vibration, and 200 per cent overpressure. It is field settable over a limited range—±10 psig set point. Accuracy is ±2 psig; repeatability, 0.5 psig. Operating temperature range is −65 to +200 F. Switch is SPST, rated 0.2 amp resistive at 28 v dc or 115 v ac. Housing is stainless steel, and all seals are metallic. Diameter is ¾ in., over-all length is ¾ in., weight, 1.5 oz. **Aero Mechanism Inc.**, 13866 Saticoy St., Van Nuys, Calif.



Circle 545 on Page 19

Spacer Bushings

in lengths from ½ to 3 in.

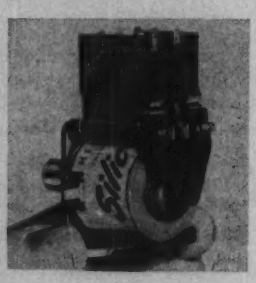
Standard hardened and ground, precision, steel spacer bushings are available in sizes from ⅜ to 8 in. ID and 9/16 to 9¼ in. OD. Lengths range from ½ to 3 in. Bushings are recommended for spacing components such as gears, and for providing smooth, hardened sections on shafts and in housings, as guide bushings and surfaces for positioning bearings and seals. **Detroit Ball Bearing Co.**, 110 W. Alexandrine, Detroit, Mich.

Circle 546 on Page 19

Time-Delay Relay

switches up to 5-amp loads

Type B hydraulic-magnetic time-delay relay with totally enclosed snap-action contacts switches up to 5-amp loads, either SPDT or DPDT. Unit has a continuous-duty coil; it does not have to be de-energized after each actuation, but can remain locked-in indefinitely. It functions as both a delay device and a load relay, eliminating need for slave or auxiliary circuits. Balanced armature construction confines the armature to either of two positions, so that there is no opportunity for tentative actuation under conditions of moderate shock and vibration. Relay is available in 16 standard timings from ¼ to 120 sec, and can be supplied for either ac (60 cycles) or dc operation. Standard ac voltages range from 6 to 240 v; dc, from 4 to 120 v. Contact capacity is 5 amp at 125 or 250 v ac; 5 amp at 30 v dc, resistive; 3 amp at 30 v dc, inductive. Relay measures 2.1 x 1.8 x 2.1 in. and weighs 3.5 oz. **Heinemann Electric Co.**, 376 Magnetic Drive, Trenton 2, N. J.

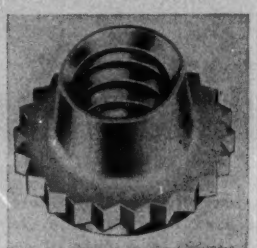


Circle 547 on Page 19

Stainless-Steel Fastener

for temperatures to 800 F is self-locking

Small, lightweight, stainless-steel fastener is designed for installation in sheets 0.040 in. thick and up. Unit is self-locking, with high push-out and torque values, and is flush on reverse side of sheet. It is suitable for temperatures to 800 F, and for use in materials with hardness of Rockwell B 75 or less. Class 3-B threads are coated with dry-film lubricant. Available sizes are No. 4 to 10. **Penn Engineering & Mfg. Corp.**, Doylestown, Pa.



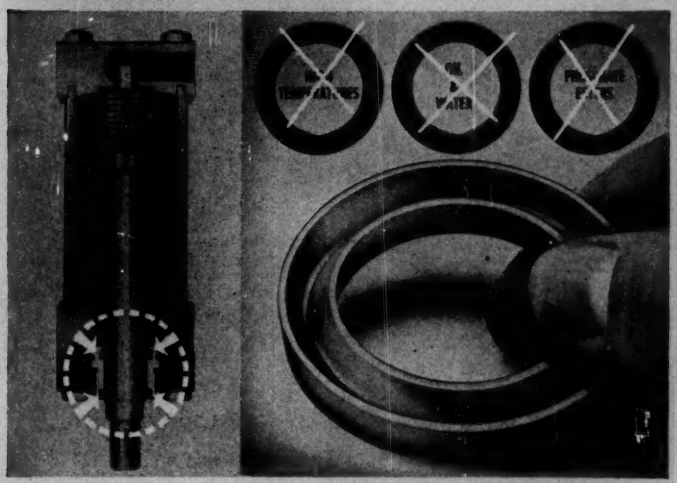
Circle 548 on Page 19

Plain, Rod-End Bearings

have static load ratings from 225 to 2550 lb

Monoball two-piece, miniature, self-aligning, spherical plain and rod-end bearings are now available in volume production. BMP miniature units are furnished in bore sizes from 0.046 to 0.156 in. with ultimate static load ratings from 225 to 2550 lb. They are offered only in corrosion-resisting steels.

3M COMPANY **CHEMICALS** *THE RAW MATERIALS OF PROGRESS*



One seal of FLUOREL® BRAND ELASTOMER does work of three!

High-heat capacity, chemical inertness help cylinder-maker eliminate special seals!

"Now seals of Fluorel Brand Elastomer handle all three requirements better!" reports Hydro-Line Manufacturing Company, a Rockford, Ill., maker of hydraulic cylinders for high-speed assembly machines. Formerly, three types of seals had to be stocked . . . one for high-temperature mineral oils, another for water and mineral oils at normal temperatures, still another for phosphate ester fluids. Hydro-Line standardized on Fluorel Brand Elastomer 2141 for critical cylinder seals (see arrows above) for two reasons: 1) wide operating range, 0 to 400° F. for continuous service, to over 600° F. for short-period peaks: 2) compatibility with the various fluids used.

Compared with competitive elastomers and plastics, Hydro-Line found, Fluorel Elastomer affords greater dimensional stability as temperatures change, resists abrasion better, is less subject to radiation damage. And seals of Fluorel Elastomer do not require mechanical pressure to hold them against sealing surfaces. The block vee seals of Fluorel Elastomer, made by Chicago Rawhide, are lathe-trimmed to remove flash from edges, to permit close control and assure tight fits. For more data on Fluorel Elastomer, read "Profile" at right, then return coupon below.

Chemical Division, Dept. KCG-81
3M Company, St. Paul 6, Minn.

TELL ME MORE... about FLUOREL Elastomer

Name_____ Title_____

Company_____

Address_____

City & State_____

PROPERTIES PROFILE on FLUOREL® 2141 BRAND ELASTOMER

Fluorel Brand Elastomer 2141 is a highly fluorinated, non-flammable synthetic rubber with outstanding stability in the presence of great heat, chemicals, oils and fuels. Its exceptional Mooney Scorch Rating and safe repeat processing simplify meeting tough military specifications, other critical requirements.

RESISTS CHEMICAL ATTACK! Corrosion resistance of Fluorel Elastomer 2141 is excellent—withstands corrosive chemicals, fuels, solvents, ozone.

WITHSTANDS HEAT, COLD! Continuous service may be at temperatures up to 400°F., short-term peaks may exceed 600°F. Gehman stiffness T_{10} is 3°F. Thin sections may be bent without cracking at temperatures as low as -50°F.

LOW COMPRESSION SET! This property of Fluorel Elastomer ranges from 10% after 70 hours at 250° F. to 47% after 70 hours at 400° F.

PHYSICAL PROPERTIES. Fluorel Elastomer can be compounded to provide a wide range of desirable physical characteristics. Properties based on Chicago Rawhide's Compound No. Sirvene 429133 . . .

Specific gravity	1.87
Tear strength	190 lb./in.
Tensile strength	2,000 psi
Elongation	350%
Hardness (Shore A)	80
Fluorine by weight	60%

ELECTRICAL PROPERTIES. Typical stock provides dielectric strength (short time) of 630 volts per mil, a dielectric constant of 11.4, D.C. resistivity of 2×10^{13} ohms cm. at 50% relative humidity, and a dissipation factor of .0125.

APPLICATIONS. Fluorel Elastomer is recommended for seals and O-rings, diaphragms, fuel and hydraulic hose, brake cups, fuel cells, fire walls, pump and tank liners, air ducts, wire insulation, many other uses.

For full information on Fluorel Elastomer, return coupon, or write describing your area of interest.

"FLUOREL" is a reg. TM of 3M Co.

CHEMICAL DIVISION
MINNESOTA MINING AND MANUFACTURING COMPANY
...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

IMPERIAL D-C MOTORS

for Dependable Heavy-Duty Service

Imperial D-c Motors meet the ever-increasing demand for dependable, heavy-duty drives in nearly every industry today. Over seventy years of d-c design and application experience is behind the manufacture of these motors. Ratings from 1 through 125 hp., for constant or adjustable speeds with shunt, series or compound windings are available in all standard enclosures. When you choose *The Imperial Line* you are assured of motors that stay on the job longer... keeping production high at lower costs. Write for bulletin or contact the sales office nearest you.

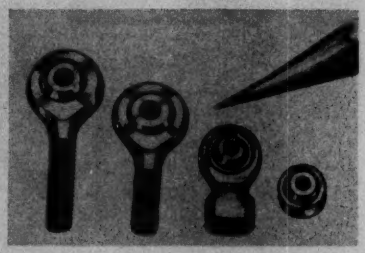
IMPERIAL
ELECTRIC COMPANY
84 Ira Ave. • Akron 9, Ohio

Semi-Guarded D-C Motor

Drip-Proof D-C Generator, SAE Flange Mounting

Totally-Enclosed Fan-Cooled D-C Motor

Two-Bearing Motor-Generator Set



Bearings provide long life in compact, light-weight assemblies. **Southwest Products Co.**, 1705 S. Mountain Ave., Monrovia, Calif.

Circle 549 on Page 19

Slip and Antistick Agent

is now available in liquid form

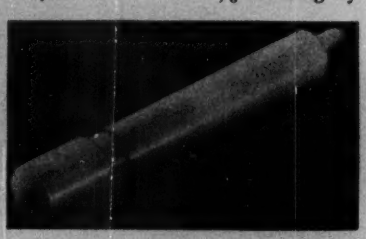
Rulon liquid reinforced fluorocarbon slip and antistick agent provides a clean, low-friction, dry surface. It is now available in pint and quart containers ready for application by brush, spray, dipping, wiping, or soaking. Liquid provides a slick surface for wood, metal, leather, plastics, and other materials. It has coefficients of friction as low as 0.07. Chemically inert, insoluble, and thermally stable to 500 F, liquid can be used as a release in molding plastics and rubber. It is also a lubricant for belts, gaskets, packings, gears, bearings, cord, cable, and machine parts. **Dixon Corp.**, Bristol, R. I.

Circle 550 on Page 19

Plastic Shock Absorbers

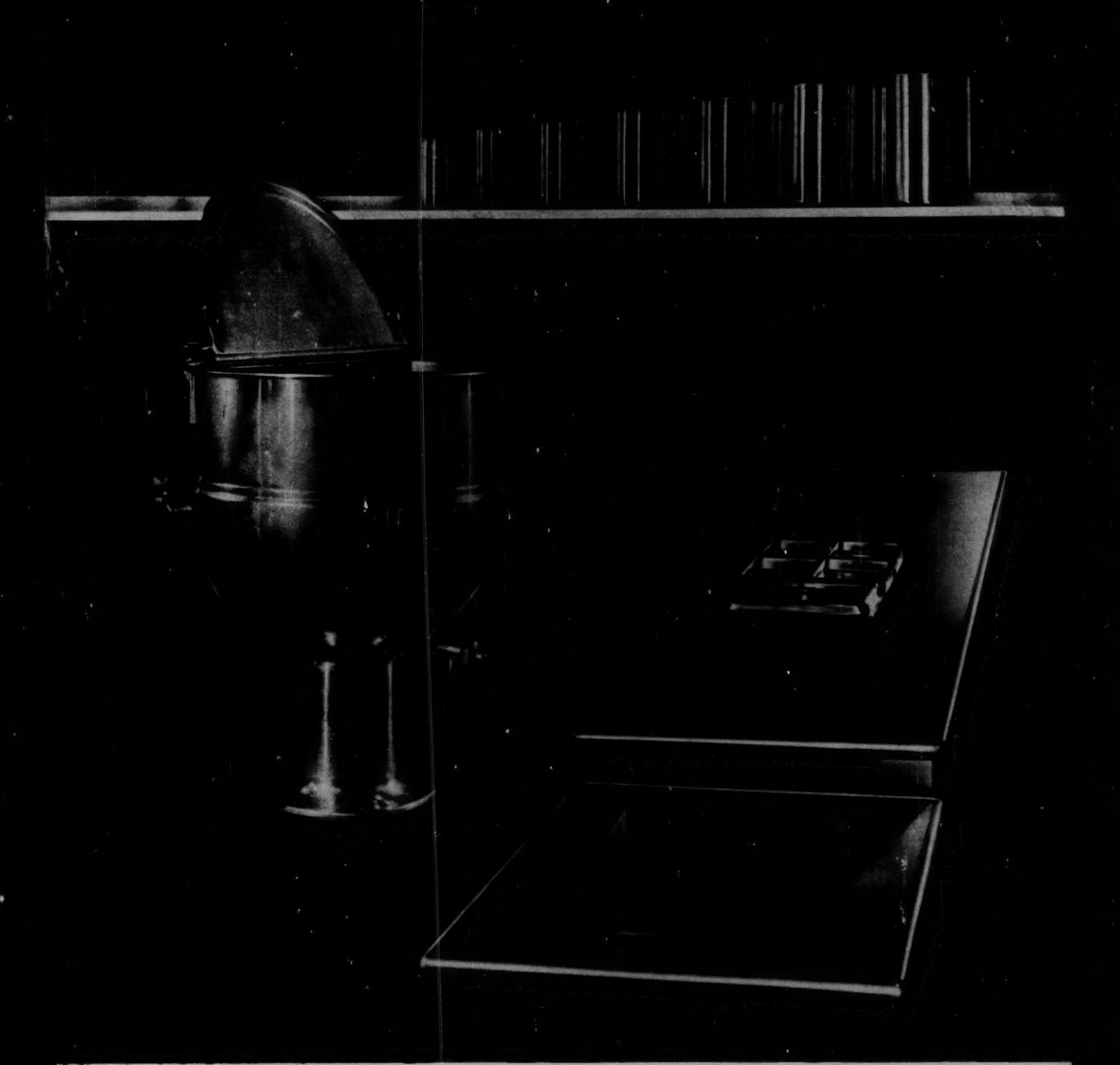
are available in single or double-action types

Plastic Liquid Dashpots in single or double-action types provide a wide range of energy-absorption capabilities to meet desired shock curves, and are available with various end fittings. The 66 standard models absorb energy from 1 to 886,000 lb-in. from 1⅛ in. long by



Circle 257 on Page 19

Circle 258 on Page 19→



It's more than a matter of taste

Wherever food and metal meet, in a processing plant or kitchen, the metal is usually stainless steel. The flavor *and* purity of food are entrusted to stainless because no other metal matches its resistance to contamination and corrosion. And none—metal or plastic—is so durable, decorative and easy to clean.

Such complete trust in a product comes only from time-tested performance—the reason J&L consistent quality stainless steel is specified by manufacturers of equipment widely used by packers and processors, and by chefs in restaurants, hospitals and hotels. By delivering quality consistently, J&L helps the food industry safeguard its products, all the way from plant to palate.

Get consistent quality stainless steel from your J&L distributor, who is backed by the full facilities of J&L's research laboratories.

Jones & Laughlin Steel Corporation

STAINLESS AND STRIP DIVISION • DETROIT 34

J&L STAINLESS

SHEET • STRIP • BAR • WIRE

ANNOUNCING MACHINE DESIGN's 1962 BOOKS PROGRAM:

THE HYDRAULICS-PNEUMATICS BOOK
Power Components

THE ELECTRIC CONTROLS BOOK
Switches, Relays and Timers

THE PLASTICS BOOK

THE MECHANICAL DRIVES BOOK

The four books to be published in 1962 will again cover subjects of vital interest to design engineers and will follow the same, easy-to-use and entirely reader-oriented style that was developed for the very first one. Each will have a Design Data Section devoted to significant selection and application information.

The contents will be authored by experts in industry, in Universities and associations, and MACHINE DESIGN editors.

The second major section will consist of a Product Directory, developed through direct mail cooperation with manufacturers and producers to insure the latest and most complete listings possible.

This entire series is designed to give you the most useful, the most complete and current reference information on important materials and components used in every-day design of products. These comprehensive reference manuals belong on the desk of every design engineer. Make sure these valuable books are coming to your department and are readily available.

MACHINE DESIGN

BASIC REFERENCE MANUALS FOR DESIGN ENGINEERS

A Penton Publication, Cleveland 13, Ohio

½ in. diam model to 70 in. long by 8½ in. diam unit. Taylor Devices Inc., 200 Michigan Ave., North Tonawanda, N. Y.

Circle 551 on Page 19

Selector Valve

for oil and lubricated-air service

Series 8600 Lo-torq selector valve permits no internal leakage in indexed positions, and little during port selection. Pressure-balanced valving disk allows easy turning. Maximum working pressures are 3000 psi for oil and 2000 psi for

lubricated-air service. Series is aluminum alloy, with Lo-torq seals of stainless steel. Sizes range from ¼ to 1 in. Republic Mfg. Co., 15655 Brookpark Rd., Cleveland 35, Ohio.

Circle 552 on Page 19

Gear Motor

fhp-unit has low noise level

Type HGM fractional-horsepower gear motor features a magnetic clutch and silent operation. Clutch disengages rotor pinion from remainder of gear train when motor is de-energized to prevent coasting of output shaft. It also provides freewheeling gear train so that output shaft can be turned manually when power is off. The two-pole, shaded-pole, ac induction motor is available in voltages from 6 to 220 v, 50 or 60 cycles. It is designed for continuous or intermittent operation, with cooling fan available in voltages from 6 to 220 v, 50 or 60 cycles. It is designed for continuous or intermittent operation, with cooling fan available for continuous-duty applications. Motor incorporates a totally enclosed, prelubricated, zinc die-cast gear reducer with stamped steel or aluminum cover. Output

ELECTRONIC "JO BLOCKS"

A. W. Haydon's microminiature elapsed time indicators and events counters are to electronics what "Jo Blocks" (Johanssen gages) are to metalworking —precisely accurate standards that are much more reliable than what they measure. Adapted from our earlier (and very successful) sub-miniature indicators, these microminiature timers have the unquestioned dependability that only A. W. Haydon's statistical production testing can provide...yet you can fit 100 of them into a 5" square ☐ We believe this new ETI is the world's smallest—only ¼ cubic inch. We know it is better than 99.9% accurate... exceeds requirements of MIL-M-26550...withstands 20g, 2000 cycles vibration...weighs only 0.75 oz.... temperature range is —65° to +250°F...and runs on a half watt, 115 v, 400-cycle power. Digital readout in hours, up to 999.9 or 9999. Companion events counters also provide 4 digit readout. Both of these units are available with a wide variety of compatible mountings ☐ For complete details on these tiny titans of time, or on any other electromechanical or electronic timing device to suit your special requirements, write The A. W. Haydon Company today.

AWH HAYDON COMPANY

249 North Elm Street, Waterbury 20, Connecticut

Circle 260 on Page 19

Why Die Stamped Circuits by Dytronics?

ELECTRICAL PROPERTIES UNIMPAIRED

Die stamped circuits are produced by a dry technique which employs a heated metal-cutting die to delineate the conductor pattern and bond it to the base material by activating the adhesive between the metal foil and the insulating material.

The electrical properties of the base material are unimpaired, because no chemicals are used, and there is no adhesive residue or residual metal on the insulating surfaces. This gives the designer the advantage of selecting base materials for physical and electrical properties without considering chemical resistance.

A new booklet, "Designing with Dytronics Die Stamped Circuits," will help you evaluate and design with die stamped circuits. Write for your free copy today.

Dytronics
INCORPORATED
ROCHESTER 47, MICH.
A subsidiary of Taylor Fibre Co.
Norristown, Pa.

Circle 261 on Page 19

speeds range from 1 to 800 rpm, with output torque up to 50 lb-in. at 1 rpm. Available output-shaft diameters are 3/16, ¼, 5/16, and ⅜ in. Output shaft can be extended from either or both sides of gear reducer. Molon Motor & Coil Corp., 3737 Industrial Ave., Rolling Meadows, Ill.

Circle 553 on Page 19

High-Strength Adhesive

requires only contact pressure

High-strength, heat-resistant adhesive can be spray-applied in a relatively dry form and requires only contact pressure. The synthetic-rubber-base adhesive, designated EC-1828, bonds all types of materials including polystyrene, sheet plastic, steel, aluminum, wood, particle board, and foamed glass. It is used in the fabrication of honeycomb sandwich panels; other applications include bonding building panels and metal assemblies. Adhesive maintains high-strength properties over a service temperature range of −30 to +250 F. Adhesives, Coatings, and Sealers Div., Minnesota Mining & Mfg. Co., 900 Bush Ave., St. Paul 6, Minn.

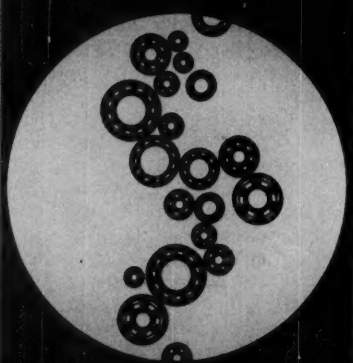
Circle 554 on Page 19

Clevis Pin

cotterless unit is self locking

New cotterless clevis pin is a self-locking unit with the main body of cadmium-plated steel and working parts of stainless steel. Eliminating the cotter saves time and effort, es-

new
LOW COST
ABEC 3 PRECISION MINIATURE BEARINGS



MINA
Bearings eliminate both economic and technical barriers to using precision miniature ball bearings in a wide variety of industrial and commercial products

MADE IN U.S.A. BY
MINA
BEARING
A DIVISION OF MPB INC.
KEENE, NEW HAMPSHIRE, U. S. A.

WRITE TODAY FOR CATALOG

Circle 262 on Page 19

Linde Coatings & materials News

LINDE COMPANY, DIVISION OF UNION CARBIDE CORPORATION

Surgical shears get longer life with LINDE tungsten carbide coating

Surgical shears with tungsten carbide coated on working surfaces now lose their cutting edge about *one-third* as fast as conventional shears. This has been proven under rigid testing supervised by a leading research laboratory.

The American Medical Instrument Corporation, Flushing, New York, uses the LINDE Flame-Plating process to improve the working surface and increase the wear-resistance properties of shears produced under its *Tuncarb* trade-mark.

The process has increased cutting life to the extent that *Tuncarb* shears in use for more than a year have not as yet been returned to AMICO for sharpening. By comparison, regular surgical shears used under the same conditions had to be returned as many as three times for restoration of working surfaces.

Coatings only .004" thick

AMICO ships hot-drop-forged stainless steel parts to LINDE's new Flame-Plating plant at North Haven, Conn. Here, via the LINDE developed coating process, a .004" thickness of tungsten carbide is actually "welded" to the precision wear surfaces of the instruments.

After coating, the blades and jaws are assembled, riveted, ground, polished, and buffed to a high finish by AMICO. The tungsten carbide surfaces themselves are finished with only a slight brushing. The same process is used to coat *Tuncarb* needle holders to provide tungsten jaws that give a firm grip on needles.

High-speed "blast-on"

The heart of LINDE's coating process is the LINDE Flame-Plating gun, into which exact quantities of oxygen, acetylene, and tungsten carbide or other powdered materials are fed by a special mechanism. After the gun is aimed at the area to be coated, controlled detonations "blast" the particles onto the work piece at speeds up to 2500 fps—until the desired coating thickness is reached.

Although temperatures of about 6000° F are attained within the detonation gun to heat powder to plastic state, the work piece itself is always kept below 400° F during the operation. There are no changes in the properties of the base metal and no distortion of the work piece regardless of its minuteness.

The inside cutting surface of the *Tuncarb* surgical shears shown here have been coated with tungsten carbide, reducing their rate of wear by as much as one-third.

In some uses, depending on the thickness of finish, the LINDE Flame-Plating process has been known to multiply wear resistance of metal parts by as much as 40 times.

For complete information on how you might use this advanced method of coating metals to improve production or reduce operating costs, check and send the coupon below.

LINDE synthetic sapphire solves guide problem in tape recorders

Second only to the diamond in hardness, LINDE synthetic sapphire provides unique wear-resisting characteristics. Because of its extremely low friction, hardness, and physical and chemical stability, several large manufacturers are using LINDE synthetic sapphire to solve the wear problem in tape guides on airborne and high-reliability tape decks, as well as in photographic film guides.

In these areas—where hardened steel guides show friction and wear almost immediately—sapphire wear is nearly imperceptible even after 100 hours of operation.

LINDE flame-polished synthetic sapphire is a convenient material for preventing edge-cutting typical with certain tapes in top and bottom guides.

For details on LINDE synthetic sapphire for any type of wear guide, instrument bearing, or other critical application, check and mail the coupon.

Chromium polished to maximum lustre with LINDE abrasives

In certain applications where it is necessary to achieve an extremely smooth surface on chromium finishes, such as in photographic rolls and processing rolls in the plastics industry, LINDE alumina abrasive powders of 99.98% purity have demonstrated unusual efficiency in removing the most minute protuberances.

Several leading photographic and precision parts manufacturers use LINDE abrasives, not only to obtain high-lustre finishes that protect materials, but also to refinish rolls several times over to avoid frequent replating.

Grades of LINDE alumina powders in sub-micron sizes are available for several cutting speeds or types of finish. For information, use the coupon below.

CHECK—CLIP COUPON—ATTACH TO BUSINESS LETTERHEAD

Linde Company, Dept. MD-85
270 Park Avenue
New York 17, N.Y.

Please send details on the items checked:

- ☐ LINDE Flame-Plating
- ☐ LINDE Synthetic Sapphire
- ☐ LINDE Alumina Abrasives

UNION CARBIDE

LINDE COMPANY

"Linde" and "Union Carbide" are registered trademarks of Union Carbide Corporation

Circle 263 on Page 19

Cured of cancer!

In August 1950, Jack Oelker, a farmer in Urbana, Ohio, went to see his dentist complaining of a sore jaw. His "sore jaw" turned out to be cancer. Today, Jack Oelker is one of more than a million Americans who have been *cured of cancer*. Read why knowing the Seven Danger Signals of cancer may someday save your life!

Jack and Martha Oelker with their children. You will see pictures of the Oelker family many times in 1961. They have been chosen as the American Cancer Society Poster Family—symbol of the fact that many cancers can be cured if detected in time.

JACK OELKER is 33 years old. Eleven years ago, he married Martha, his childhood sweetheart. Eleven years ago, five weeks after his marriage, Jack developed a sore jaw that didn't heal—and went to see his dentist.

That began the chain of events that led to the diagnosis of a bony tumor in the left jaw. Cancer. In September, 1950, Jack was admitted to University Hospital in Columbus, for surgery.

His doctor's verdict

Jack's doctor writes: "Since then, he has been rechecked at intervals and he has remained free of the disease. At the present time, he is able to carry out his normal activities, and shows no further evidence of tumor."

What are Jack Oelker's normal activities? Very much the same as yours and mine. The Oelkers like basketball games and picnics. They bowl.

The three Oelker girls, Susan, age 8, Sandra, age 6 and Carol Ann, age 4, have their father with them today because Jack Oelker acted promptly at the first sign of a "danger signal" and was properly treated *in time*.

There are two important ways that *you* can fight cancer. With a *checkup and a check*. An annual checkup—and a check to the American Cancer Society.

Where your money goes

Your check supports cancer research. Makes possible grants to research institutions. Provides fellowships to scientists engaged in cancer research. Educates the public to lifesaving facts about cancer. Helps maintain a program of service to the stricken.

A checkup and a check. Worth remembering. And so are the 7 Danger Signals listed to the right.

The 7 Danger Signals of Cancer

1. Unusual bleeding or discharge.
2. A lump or thickening in the breast or elsewhere.
3. A sore that does not heal.
4. Change in bowel or bladder habits.
5. Hoarseness or cough.
6. Indigestion or difficulty in swallowing.
7. Change in a wart or mole.

If your danger signal lasts longer than two weeks, go to your doctor immediately. Only he can tell if it is cancer.

AMERICAN CANCER SOCIETY

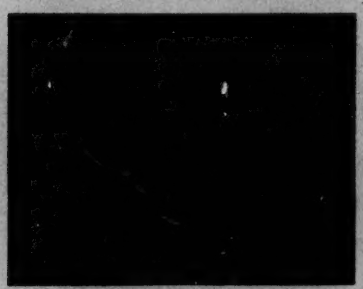
pecially for blind assembly or where the connections are made and separated quite often. Pin is furnished in practically all sizes, with one or several locking devices as required in the body. Rein Leitzke, Department CC, Hustisford, Wis.

Circle 555 on Page 19

Germanium Mesa Transistors

have typical total switching speed of 96 nanosec

Four high-speed germanium mesa transistors are designed for switching applications. Typical total switching speed for transistors in this line is 96 nanosec, and gain bandwidth product for all types is about 600 megacycles. Designated



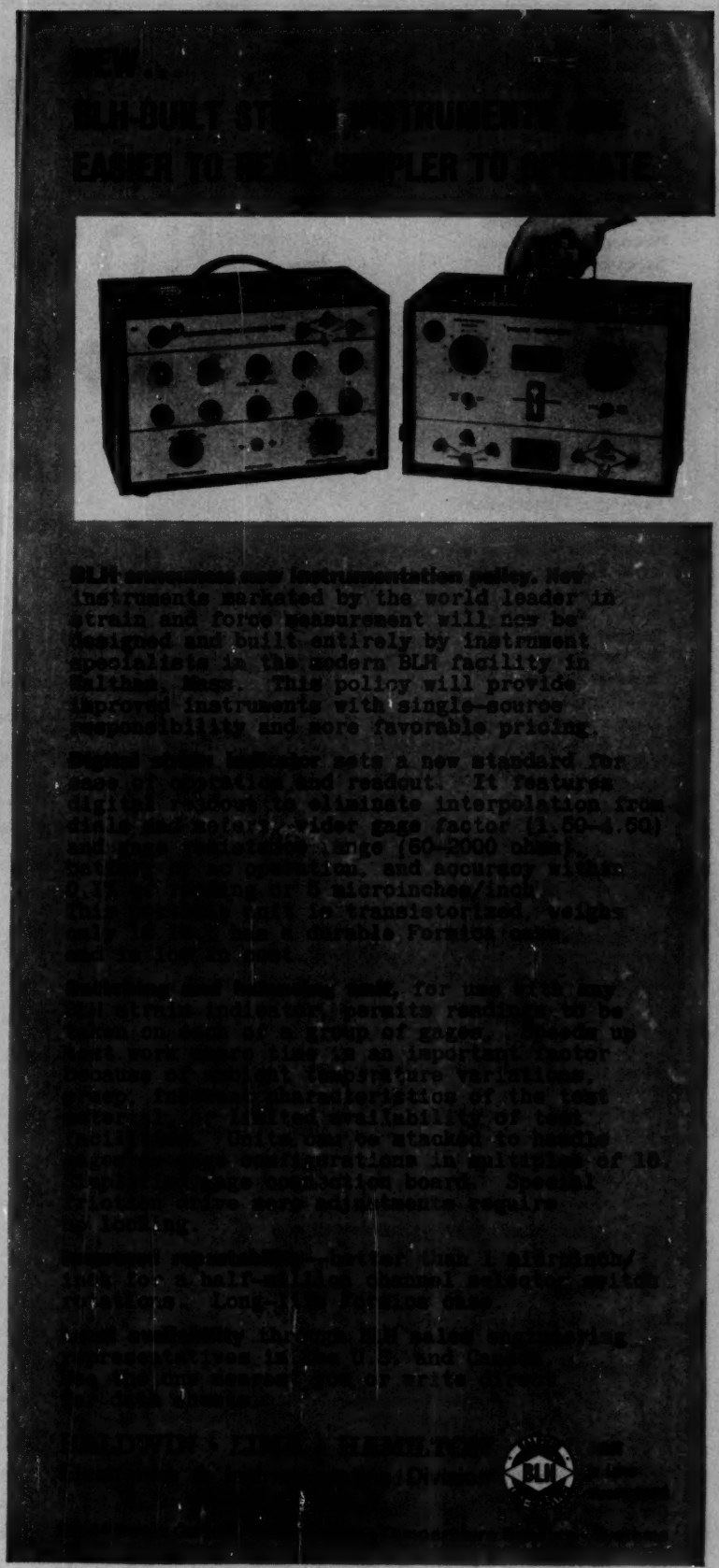
types 2N705, 2N710, 2N711, and 2N725, the transistors are housed in a package which meets JEDEC standard TO-18 outline. Semiconductor Products Dept., General Electric Co., Kelley Building, Liverpool, N. Y.

Circle 556 on Page 19

Speed Reducers

in speed ratios from 5:1 to 60:1

Universal L-mounting worm-gear speed reducers are available in 1⅛, 1¾, 2¼, and 3-in. centers in stock speed ratios from 5/1 to 60/1. Inputs range from 0.12 to 0.61 hp in the 1⅛-in. size, and from 0.86 to 5 hp in the 3-in. size. Intermediate sizes for in-between powers are available. Right-angle drive is built for continuous duty in conveyors, hoists, mixers, agitators, stokers, sprayers, and other equipment. Fully enclosed, it is suitable for mounting in any input or output-shaft arrangement. Ball-bearing-equipped units have hardened and


BLH-BUILT ST
EASIER TO
BLH announces new instrumentation policy. New
instruments marketed by the world leader in
strain and force measurement will now be
designed and built entirely by instrument
specialists in the modern BLH facility in
Waltham, Mass. This policy will provide
improved instruments with single-source
responsibility and more favorable pricing.
digital readout to eliminate interpolation from
dials and meters, wider gage factor (1.50–4.50)
and gage resistance range (60–2000 ohms),
0.1% accuracy or 5 microinches/inch.
and durable Formica cover.
BLH

Circle 265 on Page 19

1960 DATA SHEETS INCLUDE:

Planetary Gear Trains
By William H. Wilkinson
Geneva Mechanisms
By Marshall C. Smith
Cooling By Evaporation
By Robert M. Sando
Galvanic Corrosion
By Eugene D. Veilleux
Plastics For Extrusions
By Robert Marx
Low Temperature Properties
By Randall F. Barron
Thermal Stresses
By F. Caplan
Control-Movement Direction
By Joseph L. Seminara
Planetary Gear Ratios
By Reed H. Langdon
Polyhedrons
By Joseph J. Fousek
Four-Gear Combinations
By Robert G. Gerber
Calculating Weight and Volume
By M. E. Arthur
Brakes
By H. A. Borchardt
Planetary Drives
By Jacob Shuster
Fastener Vibration
By Gerard T. Klees
Acceleration Velocity Distance Time
By V. F. DeVost
Cold Heading
By E. F. Tauscher
Curved Beams
By Chen Ya Liu
Pulley Diameter vs Wire Size
By J. Paull
Compressibility of Fluids
By Robert M. Sando
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ground alloy-steel worm integral with the shaft, nickel-bronze worm with heat-treated, alloy-steel shaft, and semisteel housing with large oil reservoir. Crofts U.S.A. Inc., 2542 W. Peterson Ave., Chicago 45, Ill.

Circle 557 on Page 19

Small Fan

moves 17.5 cfm under free delivery

New 60-cps Propimax 2 fan measures slightly over 3 in. diam., 1½ in. deep, and weighs 6½ oz; yet it moves 17.5 cfm under free delivery conditions. Materials and finishes meet most applicable military specifications. Power required is 0.05 amp at 115 v, under free delivery conditions. Unit is physically and aero-

dynamically symmetrical, permitting reversing of air flow by turning end-for-end. Mounting is by means of servo-ring. Speed at free delivery is 3250 rpm. Rotron Mfg. Co., Woodstock, N. Y.

Circle 558 on Page 19

Shaded-Pole Motors

fractional-horsepower units are permanently lubricated

Shaded-pole, 4 and 5-in. diam motors incorporate new bearing-lubrication system and integral insulation for long life. The 11 and 21-frame (shown) motors are suitable for a variety of applications including gas-fired unit heaters; unit cooler fans and blowers; exhaust and circulating fans; commercial refrigeration condensing units; space heaters; refrigeration cabinets; and certain mechanical-drive applications. One-piece cast shell and bearing housing dampens vibration and minimizes magnetic and frequency pulsations. Each size can be supplied for resilient-ring or end mount-

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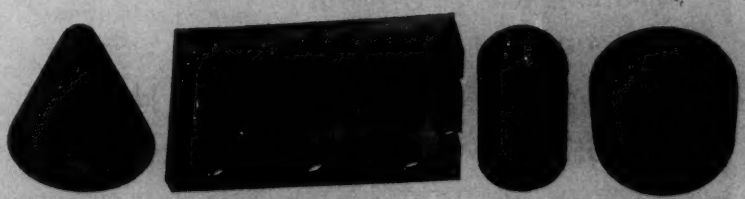

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For more information, write for "Kennertium Properties" booklet. And if you have a specific requirement, send dimensional sketch and conditions involved. Our engineers will gladly make recommendations, without any obligation to you. KENNAMETAL INC., Dept. MD, Latrobe, Pennsylvania. *Trademark

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Circle 267 on Page 19

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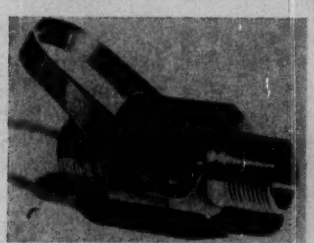
ing, and each mounting style is available in open, totally enclosed nonventilated, open with large internal fan, or totally enclosed fan-cooled construction. Motors are rated from 15 milli-hp to 1/10 hp, 60 cycles, 115 to 230 v. General Electric Co., Schenectady 5, N. Y.

Circle 559 on Page 19

Quick-Disconnect Coupling

for use with nitrogen and liquid oxygen

Quick-disconnect coupling consists of a male and female tapered connector which, when joined, forms a leakproof seal. Oxygen and nitrogen couplings are keyed differently so that the possibility of erroneous connection is eliminated. Use of a yoke-type lever permits instant disengagement with a minimum of force. Lever pivots on the female coupling and is fitted with slots that engage pins on the male assembly. By depressing the lever, male coupling is brought into position and firmly locked. Unit is constructed of a low-thermal-con-



ductivity stainless steel. Inner diameters of the male and female assemblies are identical and there are no obstructions in the flow stream. Couplings with the inner diameters ranging from ½ to 8 in. are available. Cryogenics Inc., Stafford, Va.

Circle 560 on Page 19

Turco Products uses Borg-Warner Mechanical Seals exclusively

keep bearings from being "cleaned out" on Turbulator Cleaning Machines!

From jet engines to railroad engine parts, Turco Products, Inc. "Turbulator" cleaning machines do an amazing job of cleaning every bit of a part or product quickly and efficiently.

But any leakage of this same cleaning compound past the propeller shaft can clean out bearing lubricant too, and costly bearing failure would result.

That's why Turco has standardized on Borg-Warner Mechanical Seals for all Turbulator units as the most effective shaft seal for this rugged service.

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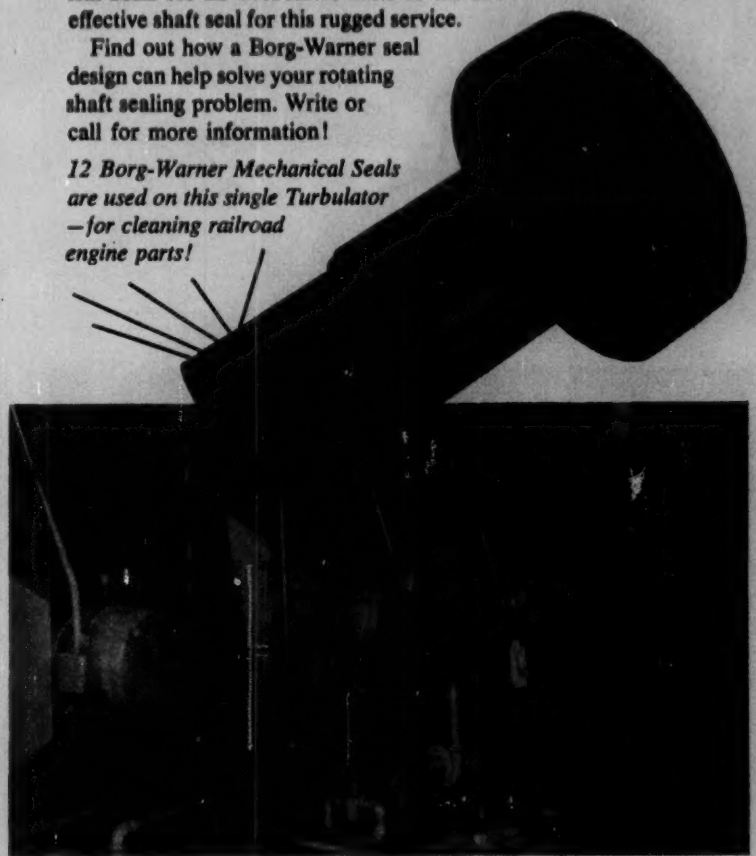
12 Borg-Warner Mechanical Seals are used on this single Turbulator —for cleaning railroad engine parts!



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Circle 270 on Page 19

ENGINEERING DEPARTMENT EQUIPMENT

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contains drafting machine, paper, pencil

Draftette sketch kit, has a new portable drafting machine mounted in an improved vinyl, self-locking binder. Portfolio fold kit includes drafting instrument, with 3 x 5 or 4 x 6 in. scale and 180-deg protractor, pad

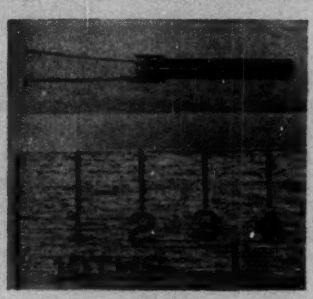
of 50 sheets of 8½ x 11 in. drawing paper, and pencil. Portfolio can be carried conveniently or stored in desk or table. Drafting instrument is anodized aluminum, one-piece scale. Kit measures 9½ x 13 x 1½ in. and weighs 1½ lb. Draftette Co., P. O. Box 794, Beverly Hills, Calif.

Circle 561 on Page 19

Strain Gage

has ultimate strain capacity of 5000 microstrain

Flexible, ultrathin, semiconductor strain gage features a U-shaped configuration with leads on the same end. Gage designated Micro-Sensor Model MS632-120, provides flexibility for reduced-radii applications, and ease of limited-area installation.



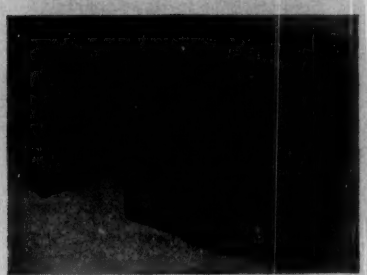
Proof-tested to 3000 microstrain, gage has an ultimate strain capacity of 5000 microstrain. Mounted on a high-temperature backing, unit has a gage factor of 110, with a resistance of 120 ohms. Operational temperature range is −320 to +400 F. Micro Systems Inc., 319 Agostino Rd., San Gabriel, Calif.

Circle 562 on Page 19

Photocopy Unit

is built into an attaché case

Attaché photocopier, a diffusion-transfer machine, is a portable unit which copies anything, providing exact, sharp prints. Case weighs 12½ lb, has natural luggage color with brass hardware and dual security locks. It can copy any original up to 9 in. wide by any length. Cut-sheet negative and positive papers are stored in the top of the case. Unit can be used in daylight or under artificial-lighting conditions. Exposure light source is an 8-w, 12-in., green fluorescent lamp, rheostat-controlled by a panel knob to compensate for varying shadings of originals. Over-all dimensions



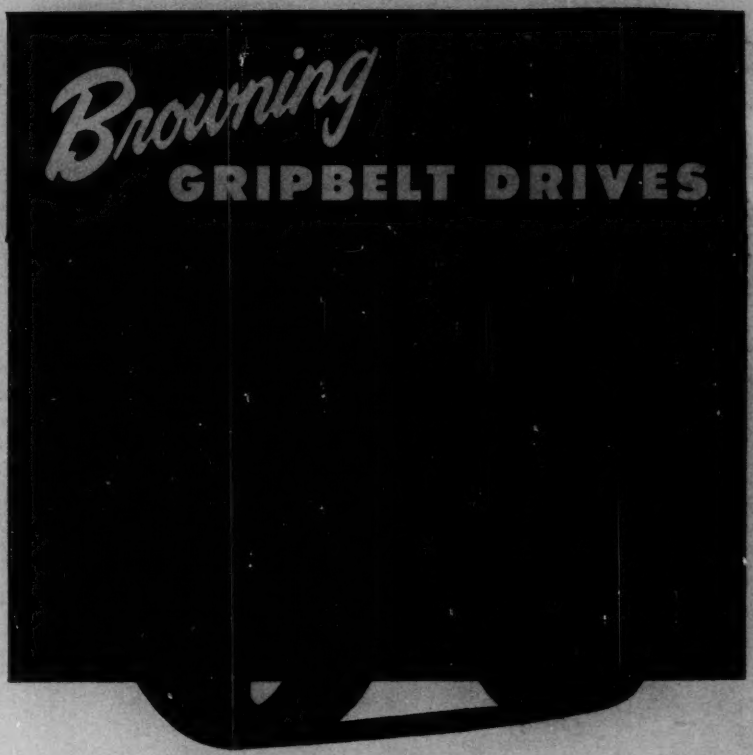
are 17½ in. wide x 12¾ in. high x 4¾ in. deep. Anken Chemical & Film Corp., Newton, N. J.

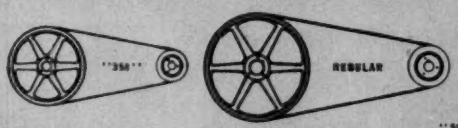
Circle 563 on Page 19

Portable Test Chamber

uses liquid CO_2 to achieve fast, controlled cooling

Continuously controllable temperature range from −100 to +200 C for simplified environmental temperature testing is available in Hi-Lo temperature test chamber, Model 3040640. Unit permits complete temperature cycling in one installation. It uses bottled liquid CO_2 to achieve fast cooling with precise con-



The "358" Gripbelt is narrower and deeper than regular types, providing efficient, more compact V-drives  with fewer belt cross sections and all top-quality features

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Circle 271 on Page 19

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Circle 273 on Page 19

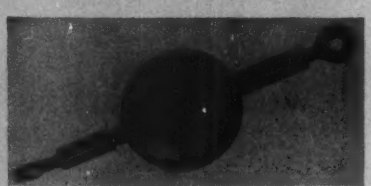
trol. A single precision heat and cold dial provides complete control of the internal temperature, and a direct-reading thermometer provides continuous visual monitoring. Provisions for pneumatic and electrical connections are built in. Giannini Controls Corp., 1600 S. Mountain Ave., Duarte, Calif.

Circle 564 on Page 19

Load Cells

for use in temperatures from −300 to +750 F

Load cells designed to measure both tension and compression over a wide range are available in seven stock models with full-load ratings from 1000 as 100,000 lb. Units rated as low as 100 lb or as high as 500,000 lb are available on special order. Sensing function of the force-measuring transducers is performed by resistance-wire type, high-temperature, weldable strain gages in a bridge configuration within a ring. Units are conservatively rated; they can be overloaded as much as 50



per cent without destroying calibration. Method of temperature compensation provides high stability in the presence of wide and rapid changes in temperature. Units can be used without damage in temperatures from −300 to +750 F. Recommended input voltage is 10 v with a maximum of 15 v allowable; nominal output voltage is 25 mv full scale with 10 v input. Microdot Inc., 220 Pasadena Ave., South Pasadena, Calif.

Circle 565 on Page 19

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Engineering Fundamentals for Professional Engineers' Examinations. *By Lloyd M. Polentz; 366 pages, 5¼ by 8 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$9.50 postpaid.*

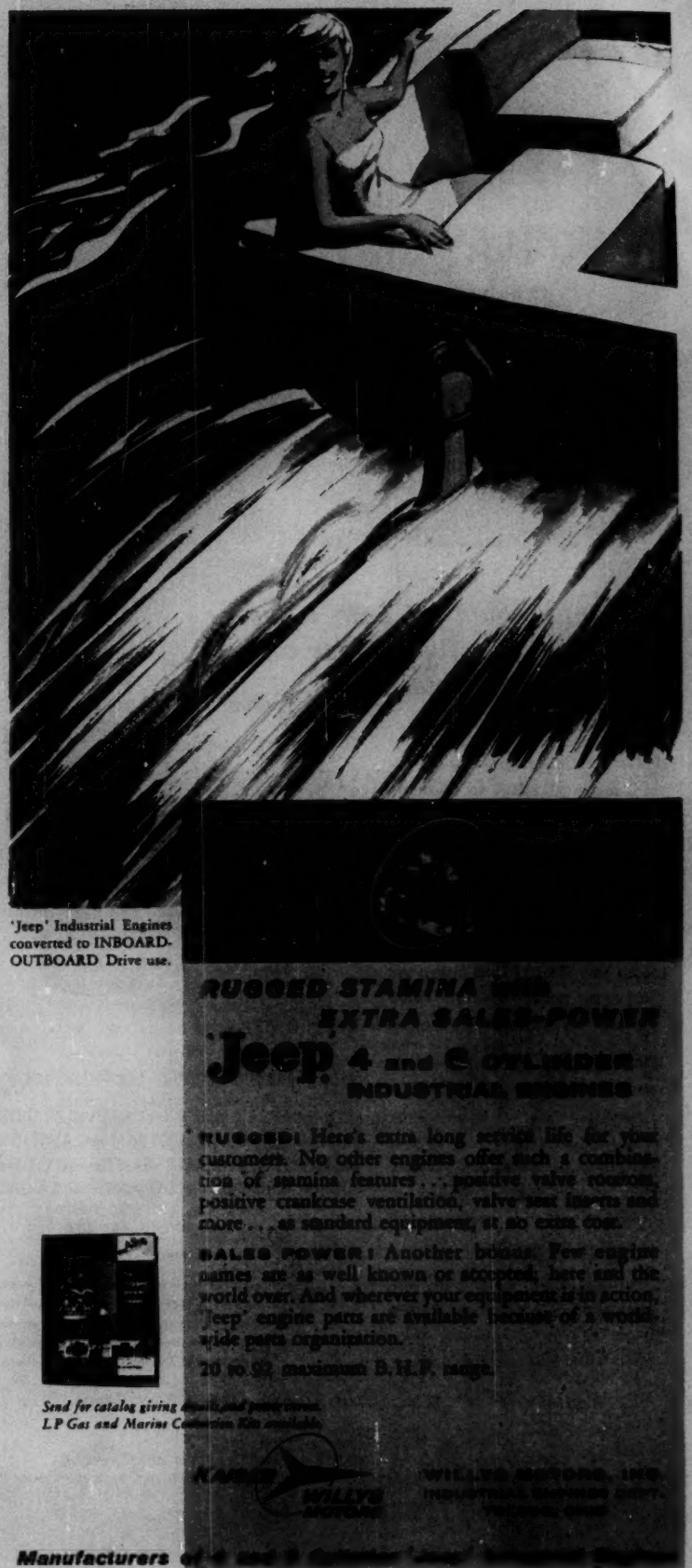
A comprehensive review of engineering fundamentals is presented for the closed-book fundamentals section of state licensing examinations. Particular attention is given to the eight fields of engineering that ordinarily appear on the examinations: mathematics, mechanics, fluid mechanics, thermodynamics, mechanics of materials, electricity and electronics, chemistry, and economics and investment theory. Principles of physics, as they apply to the various subjects discussed, are interspersed throughout.

Electronic Packaging with Resins. *By Charles A. Harper; 339 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$11.00 postpaid.*

This book is a practical guide and reference for applications involving casting, potting, impregnation and encapsulation of electrical and electronic components and systems. Materials discussed include epoxies, polyesters, silicones, urethanes, polysulfides, and others. Many different material classes are included such as foams, low density systems, high thermal and electrical conductivity compounds, environmental resistance systems, and the new epoxy systems such as novalacs, and epoxidized polyolefins.

Engineering Management and Administration. *By Val Cronstedt; 345 pages, 5¼ by 8 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$8.50 postpaid.*

This is essentially a how-to reference book for operating an engi-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Circle 275 on Page 19

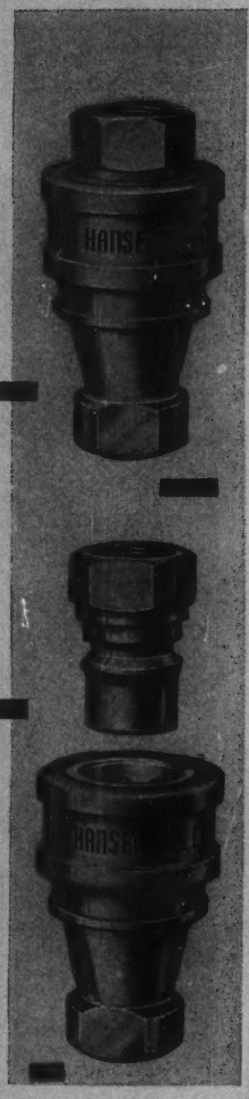
HANSEN

TWO-WAY SHUT-OFF COUPLINGS

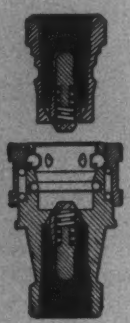
QUICK — CONNECTION OR DISCONNECTION OF FLUID LINE CIRCUITS

INSTANT — AUTOMATIC FLOW OR SHUT-OFF

Instantly shuts off both sides of circuit...prevents loss of liquid, gas or pressure



When Coupling is disconnected, identical valves in both the Socket and Plug provide instant shut-off of gas or liquid. To eliminate leakage or spillage during disconnection, the Coupling is so designed that shut-off takes place *before* the Plug separates from the Socket—and *before* the seal of the Socket itself, provided by the Socket "O" Ring, is broken.



In reverse, when Coupling is connected, the "O" Ring in the Socket completely seals Coupling *before* valves release flow of fluid from both sides of circuit—thus eliminating possibility of spurt of gas or liquid during instant of connection.

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neering department in the modern industrial plant. It is designed to supply ready solutions to the administrative problems that arise in engineering departments of all sizes. Samples of policies are introduced, as well as procedures and practices to be used as guides in the preparation of company manuals.

Guide to Metallurgical Information. *Edited by Elizabeth W. Tapia; 85 pages, 8½ by 11 in., paperbound; published by Special Libraries Association, 31 East Tenth St., New York 3, N. Y.; $4.00 per copy.*

This bibliographical guide describes more than 600 books, journals, and other information sources in the field of metallurgy. The coverage includes societies, trade associations, research institutes, government agencies, and technical services. The scope is world wide and reference sources published within the last 20 years are emphasized.

Government Publications

OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

TN D-804. Natural Frequencies and Mode Shapes of Liquids in Oblate Spheroidal Tanks. By H. Wayne Leonard and William C. Walton Jr., Langley Research Center; 24 pages, 7¼ by 10¼ in., paperbound, stapled; $0.75 per copy.

Experimental investigation was conducted on the character of free vibration modes of liquids in oblate spheroidal tanks applicable in missile systems. Measured natural frequencies were obtained for the lowest three or four antisymmetric modes of oscillation as a function of liquid depth.

TN D-863. Stress Concentrations in Filamentary Structures. By John M. Hedgepath, Langley Research Center; 30 pages, 8 by 10¼ in., paperbound, stapled; $0.75 per copy.

Theoretical analyses are made of the stress distributions in a sheet of parallel filaments which carry normal loads and are imbedded in a matrix which carries only shear. Static and dynamic stress-concentration factors due to one or more filaments being broken are determined. Particular attention is paid to the dynamic overshoot resulting when the filaments are suddenly broken.

TR 58-452. Metal Fiber Reinforced Ceramics. By J. R. Tinklepaugh, B. R. Goss, W. R. Hoskyns, J. H. Connor, and D. D. Button, Wright Air Development Div.; 77 pages, 8¼ by 10¾ in., paperbound, stapled; $2.25 per copy.

The flexural properties of a ceramic-metal fiber system were studied. It was determined that metal fiber assumes a part of the load which is to some degree in proportion to the relative elasticity moduli of the ceramic and metal. The ceramic fails when its strength is exceeded but the composite does not fail until the metal fibers are broken or pulled out of the ceramic.

PB 171113. Chemical Milling. By C. H. Rose, Watervliet Arsenal; 23 pages, 7¾ by 10¼ in., paperbound, stapled.

This paper describes a process study outlining the capabilities and limitations of chemical milling, the material for which it is suited, and the accuracies and surface finishes expected. Forty-two pounds of 4340 steel were removed from a 90-mm M41 breech ring in 61 hours by chemical milling. Surface finish was 62 microinches. Metal removal rate was 0.0007 in. per min.

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AC Motor Control, by J. Ronald Wickey and Arthur S. Newman, Jr., 1960-1961 (40 pp.) $1
Preventing Fatigue Failures, by F. B. Stulen, H. H. Cummings, W. C. Schulte, 1961 (32 pp.) $1
Simplified Vibration Analysis by Mobility and Impedance Methods, by R. P. Thorn & A. H. Church, 1959-1960 (80 pp.) $2
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Special Report on Electric Motors, Staff Report, 1958 (42 pp.) $1
Electronic and Electric Power Supplies (Symposium), 1958 (40 pp.) $1
Human-Factors Engineering, by J. D. Vandenburg and C. T. Goldsmith, 1958 (32 pp.) $1
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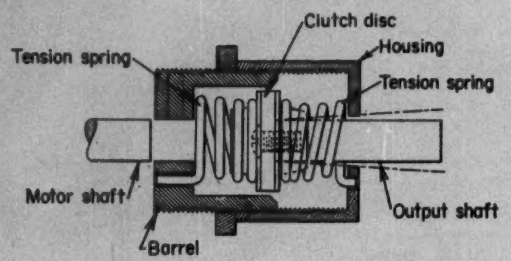
Polar Ware Co.

2500 Lake Shore Road — Sheboygan, Wisconsin

NOTEWORTHY Patents

Combination Clutch and Flexible Coupling

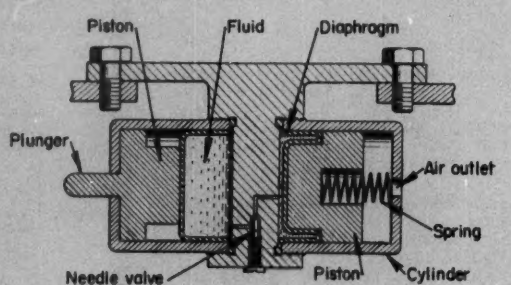
A combination clutch and flexible coupling for fractional-horsepower motors permits as much as 15 degrees of shaft misalignment without affecting the efficiency of power transmission. The assembly comprises a clutch body composed of two barrels which are



threaded together, a clutch disc, and two springs and washers. Rotation of the input shaft is transmitted to the clutch body and, in turn, to the left-hand spring, left washer, clutch disc and output shaft. Action of the left-hand spring rotates the clutch disc even though the disc and springs may not be normal to the shell axis. *Patent 2,991,637 assigned to General Electric Co., New York, by Elmer E. Lochow.*

Delay Timer

A needle valve controls fluid between two opposed pistons to slow down movement in a mechanical system. As pressure is applied against the tongue, the lower piston moves upward in the lower cylinder, distorting the diaphragm so that it folds back in the

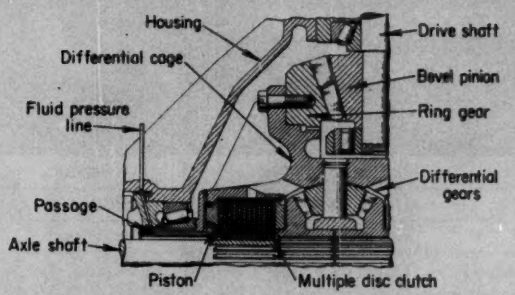


recess. At the same time, fluid is forced from the lower chamber into the upper chamber against the action of the spring and needle valve. When the pressure against the tongue is released, the spring

pressure causes the pistons to return to their original positions. *Patent* 2,991,992 *assigned to Aeroquip Corp., Jackson, Mich., by Edward C. Elsner.*

Clutch-Lock Differential

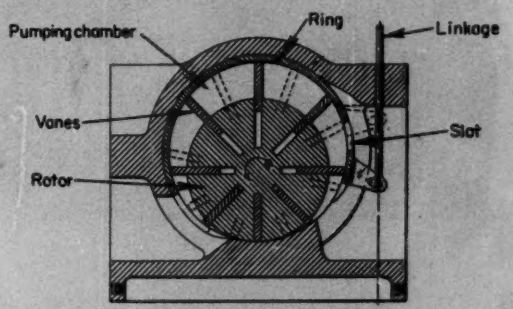
A differential for earth moving machines can be locked to transmit power equally to all wheels. An annular cavity in the differential cage forms the clutch housing and the clutch elements are actuated by a fluid piston. When fluid pressure is applied to the piston it



locks the differential cage directly to the axle shaft. Since the differential cage is connected to the differential pinions, and the face gear is secured to the axle, the entire differential is locked. *Patent* 2,991,664 *assigned to General Motors Corp., Detroit, Mich., by Ralph J. Bernotas.*

Variable-Discharge Compressor

A crescent-shaped ring adjusts to alter the compression ratio of a rotary compressor according to the load on the system. The ring automatically varies the size of the discharge outlet and at the same time maintains the cutoff point for fluid entering the suction inlet. An operating linkage at the inlet side is actuated with a change in load to alter ring position. *Patent* 2,991,930 *assigned to Worthington Corp., Harrison, N. J., by Herbert E. Lindner.*



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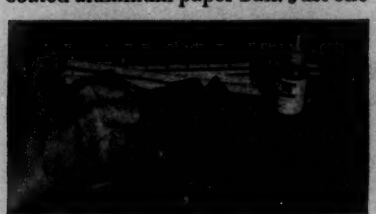

Eastman 910 Adhesive will form bonds between almost any plastics or other materials. Like to see for yourself? Just send $5 for a trial kit to use on your toughest job. Kits and more information are available from Armstrong Cork Company, Industrial Adhesives Division, 9106 Dean Street, Lancaster, Pa.; or from Eastman Chemical Products, Inc., subsidiary of Eastman Kodak Company, Dept. M-8, Chemicals Division, Kingsport, Tennessee.

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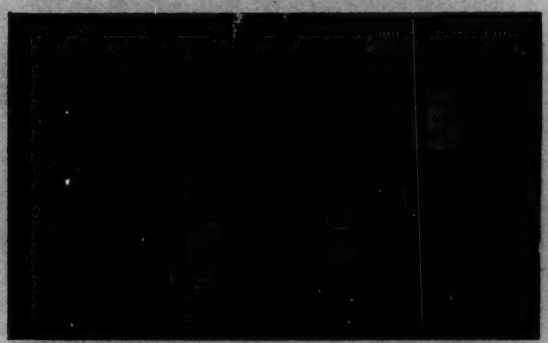

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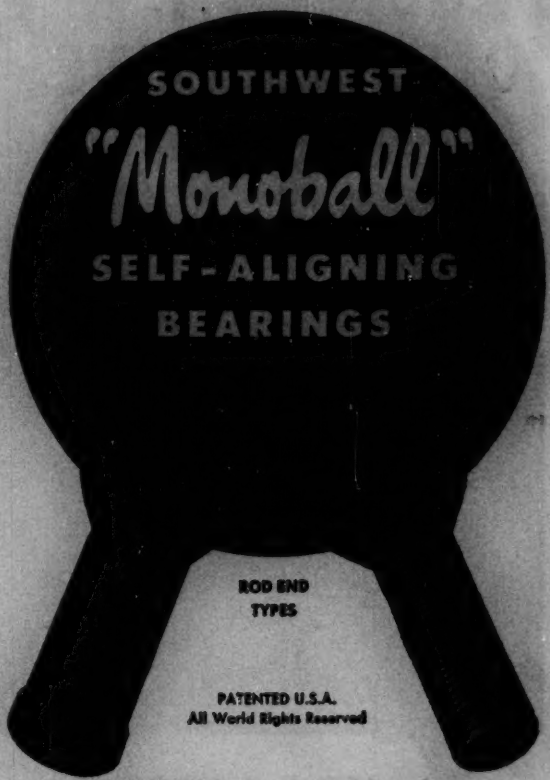

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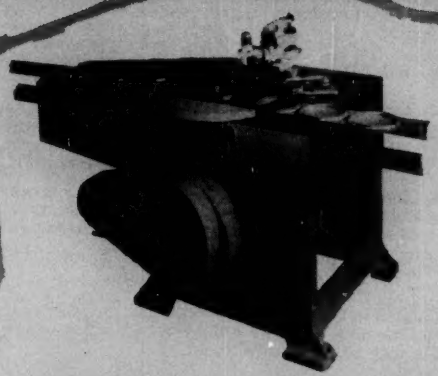

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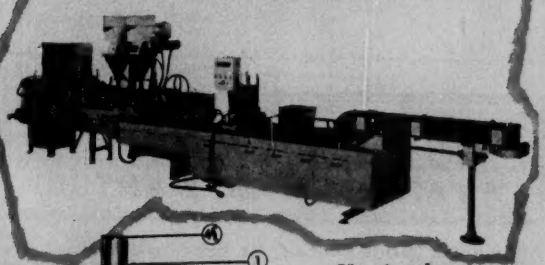

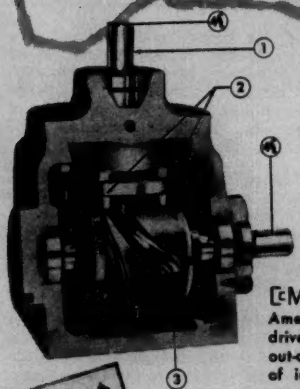

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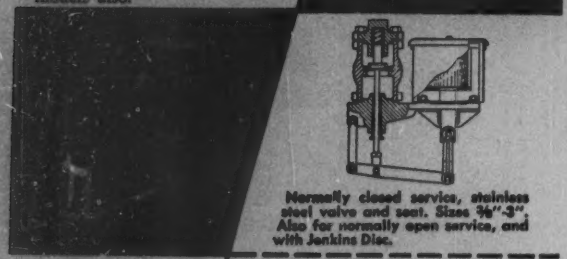

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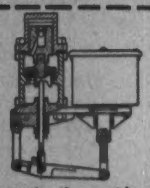

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MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

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BPA NEP

backtalk——

—Melting Pot for Ferrous Facts

MACHINE DESIGN's newest "iron in the fire" of design-engineering literature—the Books program—has produced volume number four, *The Ferrous Metals Book*. Those of you who saw it first probably have it on your bookshelves; the rest of you need not despair, fortunately, because we have extras and you can send for your own copy.

This book, like our Fasteners, Seals, and Bearings books, is divided into two parts: A Design Data section and a Product Directory. There are 30 data sheets, each containing all the mechanical, physical, and fabrication characteristics for a small group of similar alloys. About 150 different kinds of metals are covered.

The Ferrous Metals Book is easy to own. Just send $2 to Reader Service, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

—Book by Its Cover Dept.

You probably noticed the cover of our last issue—it was black and white and gray and purple and green and blue and had the symbol for a pump surrounding the ratio $2\pi\mu N/\Delta p$.

The cover was inspired by the article "Hydraulic Pumps and Motors," and George Farnsworth's inimitable touch made even the ratio look like more than just a collection of Arabic, Greek, and English characters. In fact, if you have an imagination as vivid as George's, or if you hold the magazine in front of a mirror,* you will see that $2\pi\mu N$, a la Farnsworth, is "Nuts" spelled backwards.

Furthermore, George, "nuts" spelled backwards is "stun." And we think your covers are stunning.

*This practice is not recommended for reading the rest of MACHINE DESIGN.

—Word Weigher

Described as an accessory "for the desk that has everything," this gadget may also provide a means of diversification for the engineer who usually toys with his slide rule while talking and/or thinking. When used for its intended

purpose, the Stamp Teller weighs letters. The envelope is placed perpendicular to the handle, and a metal weight slides along the scale, which is graduated from ½ to 2 oz. Great accuracy is not claimed for the Stamp Teller, but it does indicate whether a letter needs one or two stamps. The pointed end slits envelopes, and the handle magnifies. The tool is molded of Du Pont's Lucite and Delrin for Morgan Development Laboratories Inc., New Canaan, Conn. Three dollars.

—No-How

Turning down an invitation is always hard to do, and this holds true for an aspiring author's invitation to publish his work in MACHINE DESIGN. Although we accept many "over-the-transom" articles, we must also reject a fair number. When we say "No," we explain why, then we don't usually hear from the author again until he submits another manuscript. One writing team, however, recently responded to the return of their latest brain child as follows:

> What a mortuary engineer you could be! The gentle hands, the kind words, the distinct radiations of departed spirits—simply tremendous qualifications. Not to mention the tears. You handle the hemlock cup so deftly that it is a pleasure to have had it.

Not everybody is so tickled over a rejection letter, of course, and it should be noted that these authors—during the development of previous articles—have grown to be friends of the editor who spurned them.

and here's how Pheoll solved it

A recent development by Pheoll has made this fisherman's regular job a lot easier. The job . . . that of electrician.

Specifically, Pheoll has done away with all the red tape—or should we say "black tape"—involved in setting up wiring systems. Now, to make an electrical connection there's no need for tape to tape and tape the wires together. A set of Pheoll designed shouldered brass screws, built into a small plastic case, form handy binding posts around which the wires can be wound and joined. The electrician clamps on the lid, screws it down tight . . . and the connection is made . . . quickly and permanently. No tape deterioration. No shorts.

This is typical of Pheoll experience . . . the application of creative engineering to basic, everyday fastener problems . . . that can be helpful to your company.

Why not call or write Pheoll today?

Pheoll Manufacturing Company, Inc.
5700 WEST ROOSEVELT ROAD CHICAGO 50, ILLINOIS

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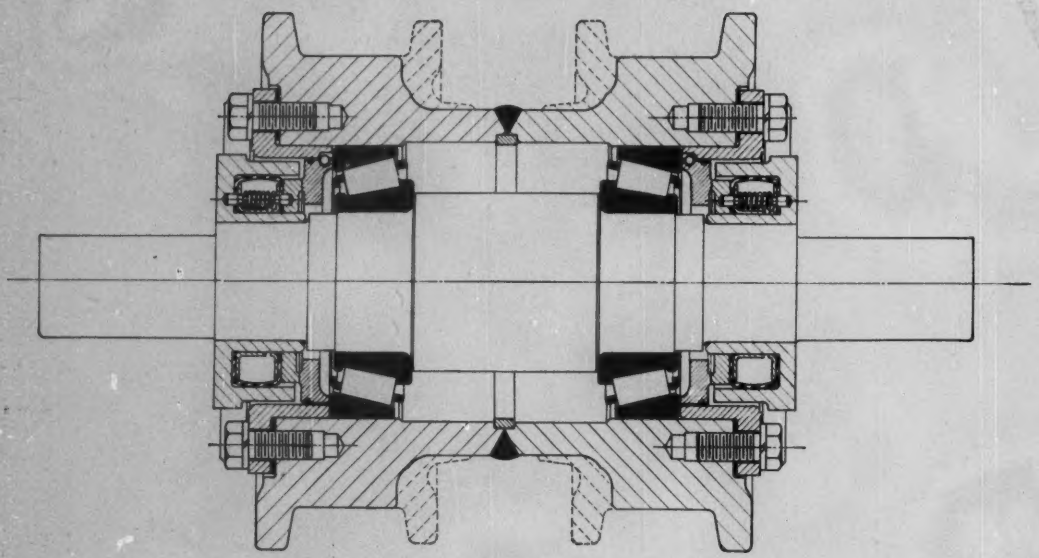
PHEOLL

P

HEADING THE FASTENER INDUSTRY FOR OVER 50 YEARS

How Allis-Chalmers reduces maintenance, boosts work capacity of their crawler tractors



To design *both* greater work capacity and reduced maintenance into their crawler tractors, Allis-Chalmers engineers used Timken tapered roller bearings for the heavy duty track rollers.

Timken bearings work with the steel sealing rings to effect a positive seal that makes one-time lubrication possible. Timken bearings keep all parts precisely aligned. They protect the seal by minimizing side thrust and wobble, eliminate wear that makes bushing-type assemblies impossible to seal positively. And the tapered design lets Timken bearings take *both* radial and thrust loads. Full-line contact between rollers and races provides extra load-carrying capacity—extra work capacity.

And to deliver more power where it's needed, Timken bearings are also used in the bevel and clutch shaft, final drive pinion, intermediate and sprocket shafts, track idlers and support wheels.

ENGINEERING ASSISTANCE, early in the design stage, helps manufacturers stretch bearing dollars. Timken bearing engineers have the training to do the job and are eager to help you.

METALLURGICAL LAB develops the steels that will make tomorrow's Timken bearings last even longer, help customers to design more economical and durable bearing applications.

The Timken Roller Bearing Company, Canton 6, Ohio. Cable: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits. Canadian Division: Canadian Timken, St. Thomas, Ont.

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